

REFLECTING SEXTANT,

AND ITS

USE, AT SEA.

THE Arch of the Sextant is one sixth of the circumference of a Circle, which is 60 Degrees.

The Arch of an Octant is one eighth of the circumference of a circle, which is 45 Degrees.

By the Principles of Optics, the Image of any object when seen in its second reflection, appears to be fixed, although the instrument be in motion at the same time; and by moving the Index on the Arch 45 Degrees, or the 8th of a Circle's circumference, it will measure its double, or 90 Degrees; and the like of any other number of Degrees. Therefore, the Sextant's Arch will, from the same cause, measure the angular Distances of Objects 120 Degrees, and make the image of one of them appear to coincide with the other object.

The method of using the Octant and the Sextant is the same, and these instruments are equally useful in measuring altitudes; but in taking the distance between the Sun and the Moon, or the Moon and Stars, when their distance exceeds 90°, the Sextant must be used; by which the longitude of a ship at Sea may be ascertained, and in many circumstances when less distances than those which exceed 90° cannot be observed.

By the use of this admirable instrument and the many opportunities for observation which so frequently offer, the longitude may be determined to the great advantage of those concerned in the navigating of ships.

The finding the latitude and longitude at sea is of the utmost consequence, particularly when the Commander of a ship wants to make a Channel, Bay, Cape, or the like, and to determine which, in bad weather, requires the Skill of the best and most able artist.

The first and principal thing is to determine the latitude, and the second to determine the Longitude. There are several methods to obtain each of them; but the Latitude Observations are much the more certain and useful.

Were the several methods more generally known and practised than they are; they would be the certain Means of securing from danger; Lives, Ships and Cargoes, which, through the want of this knowledge, they too commonly are exposed.

To set the fore Observation, or Object-Glass, perpendicular to the Plane of the Instrument.

Take the perpendicular Distance between the Plane of the Frame, and that Part of the Object-Glass, which is between the Quicksilver'd and the unquicksilver'd Part;

set



set that Distance above the Plane, on the Eye-vane, and mark it so that you may see it by Reflexion through the Hole, in the Eye-Vane upon the Object-Glass.—You must take the Finger Screw out of the Lever of the Object Glass, and then turn the Glass by the Lever and Nut, 'till the Plane of that Glass be parallel to the Eye, and you will then see the Reflexion of your Eye, as also that of the Mark by the Eye-hole, and the Eye-hole of the Eye-vane, and then observe whether the Reflexion of the Mark be reflected from that part of the Glass above or below the Line of coincidence of the open, and the reflective Part; If either be the Case, you must adjust it by turning the Screws which are in the Front and Tail of its Frame, till the marked Part be reflected from its parallel Part in the Object-Glass, which will be done when the Glass is Perpendicular or nearly so.

To Set the Index-Glass parallel to the Object-Glass, and perpendicular to the Plane of the Instrument; and to Adjust the Object Glass.

Set the Index to (0) that is, its fiducial Line, on the Nonius, where the Minutes of it begin, to the beginning of Degrees on the Limb, or Arch of the Instrument; then look through the Eye-Vane and Object-Glass at the edge of the Sea, and turn the Object-Glass by its Nut and Lever, or by the Finger-screw, 'till you make the reflected edge of the Sea appear on the quicksilvered Part of the Object-Glass, and the Horizon, seen through the open Part, to be coincident, or to be in one and the same Line; then screw down the Lever by the Finger-Screw, and the Sextant or Octant will be horizontally adjusted: The next thing is to adjust its vertical Position; on Shore, it may be done by looking through the Eye-Vane and Object-Glass at an erect Pole, the corner of a Building, or the like at a considerable Distance, which, suppose at one-fourth, or half a Mile from you, and if the Object and its Image do not coincide, you must make them, by turning the Screws in the Front and Tail of the Frame of the Index-Glass. This adjustment may be made on board a Ship by looking at the Topmast or Top-gallant-mast, or by holding the Plane of the Instrument parallel to the Horizon, and then making the real and reflected edges of the Horizon coincide. But the best method of adjustment, for both the Vertical and Horizontal positions, is by the Sun; Thus with a Sextant which has a dark Glass that turns upon a Screw over the Hole of the Eye-Vane, occasionally; by looking through it at the Sun, you may adjust both Positions by the Screws above mentioned.

To adjust it in the best Manner possible; put the Telescope with its dark Glass into the Eye-Vane, loosen the Screw of the Lever of the Object-Glass; set the Index to (0) and screw it fast, then look through the Telescope and through the Object-Glass at the Sun when it is Ten, Twenty, or more Degrees high; and make good the horizontal Adjustment, by the Finger-screw of the Object-Glass, made for that purpose, then make the Vertical Adjustment by the Screws of the Index and Object-Glasses, repeat these adjustments till only one true Face of the Sun can be seen, and no Part of the Image, as it must coincide with the real Face of the Sun, by which the adjustment may be made to one-third of a Minute, or less. The Telescope is of great service in this Adjustment.

Note, The Edge of the sea, and the horizon denote the same.

Of



Of the ARCH of the Sextant.

The Arch is divided into 120 equal Parts or Degrees, with five or six Degrees over for the numbering of the Nonius ; * and it is numbered 5, 10, 15, 20, &c. to 120, or 125 Degrees ; these Degrees are subdivided, some into two, others into three, and others into four equal Parts, according to the Radius of the Instrument In general the Degrees are divided into three Parts, each being 20 minutes ; there is an Index which moves on the Center of the Arch with a Glass fixed over it's Center ; the index has a Vernier, or Nonius Division on it's Arch, which is made to slide over or against the Divisions of the Arch, in order to divide the Arch into single Minutes of a Degree ; thus the Grand Divisions being Degrees, and the Subdivisions twenty Minutes each ; the twenty Divisions on the Nonius must either be equal to 19 or 21 of the Arch : If 20 on the Nonius be equal to 21 common Divisions on the Arch, the Nonius must be reckoned the contrary way to the numbers on the Arch. And when the Fiducial line cuts the first Division on the Limb ; the second Line on the Nonius is one Minute from the second Division on the Limb ; the third on the Nonius is 2' from the third on the Limb, and so on : And universally, when the Divisions on the Nonius are greater than those on the Arch, they must be reckoned the contrary way ; but when they are less than the Divisions on the Arch, they must be reckoned the same way : And they must always be reckoned from the Division on the Index, which denotes the Fiducial, or First Line ; this Line, in general, is made in the middle of the Nonius Divisions, from which the other Divisions are to be reckoned, 1, 2, 3, &c. to 10 ; and if none of these stand over or against a Division of the Arch, look at the other end of the Nonius at 10, and reckon till you see a Division of the Nonius stand in the same line of direction with a line of division on the Arch ; these Minutes added to those on the Arch, cut by the Fiducial line, over and besides the Degrees, will be the Angle made or cut by the Index.

Note 1. If 20 Divisions on the Nonius, be equal to 21 on the Arch, then the space between each Division on the Nonius is $\frac{1}{25}$ th more than the space of each Subdivision on the Arch : and because the space of one Division on the Arch represents 20 Minutes, the space of one Division on the Nonius must be 21 Minutes, that is one Minute more ; consequently, the First Division from the Fiducial Line will be One Minute, the Second Two Minutes, the Third Three Minutes, and so on ; and by this method a well divided Limb and Nonius, may be truly reckoned : And if the Nonius be justly divided, you may by it examine the truth of the Arch or Limb, from 0 to 120 ; which is the best proof of the Accuracy of the Divisions.

Note 2. If 20 Divisions on the Nonius be equal to 19 on the Limb, then each Division on the Nonius is $\frac{1}{20}$ th less than those on the Limb, consequently the index must be moved One Minute towards the left, before the First division coincides with that on the Limb ; and One Minute more to the Second on the Limb, and One Minute more for the Third on the Nonius to coincide with the Third Division on the Limb ; which is Three Minutes, and so on to Four Minutes, Five Minutes, &c.

Note 3. If the Graduations, or Lines of Division be strong, the Nonius Lines may cut three or four of them on the Limb at once, which will make the counting off doubtful ;

* At these extreme Divisions.

doubtful; when this is the case, take the middle Division of them for the Minutes sought. From what has been said, it may be remarked, that the Minutes of the Nonius, must be added to the Degrees cut by the Index, and the Subdivisions of 20, or 40 Minutes, which will be the true Angular Distance required.

Note 4. The Sextants which are made in the best manner, are made of Brass, with edge bars, and of 12, 14, 15 and 16 inches Radius, and some more; the price 12 Guineas: But those made of Brass, 12 inches Radius, without edge bars, of a new Construction, the price 6 Guineas, and 8 Guineas the most complete, with fine Divisions, so that the Nonius will never cut two Divisions on the Arch at once, but it may stand so as nearly to coincide with two and then the $\frac{1}{2}$ minute may be reckoned. These fine graduations require a glass to be used to read off the true quantity cut by the index.

Note 5. The Vernier, whose fiducial line is at one end, and its Divisions continued, is much better than those which break off and begin again, because 3 or 4 Divisions must or ought to be looked at, so as to determine the true quantity cut by the Index.

To find the Number of Minutes or Seconds, that a Nonius will divide an Arch into.

Thus, Divide the Number of the Minutes contained between each Division on the Arch, by the number of Divisions on the Nonius * (the fiducial Line excepted.) Suppose the Arch divided only into Degrees, then a Nonius, with 15 Divisions, will shew each 4 Minutes,

A Nonius with 20 Divisions will shew each 3 Minutes.

A Nonius with 30 ditto will shew each 2 ditto.

If the Arch be divided into each 20', then a Nonius with 20 gives each Minute, and a Nonius with 40 each half minute.

If the Arch be divided into $\frac{1}{4}$ Degrees, or 15 Minutes each, then a Nonius with 15 Divisions, will shew each minute; with 30 Divisions it will shew each half Minute, and so of any other.

Note 6. When you observe with the Telescope in the Eye-vane, you must be very careful to slide the Eye-tube of it in and out, till you can see the Limb of the Moon the clearest and best defined possible; otherwise you will certainly make an Error in observing Distances of the Sun, or a Star, at the Limb of the Moon.

Note 7. When you observe Altitudes, hold the Sextant upright with its Arch downwards, and look at the Visible Horizon, or apparent edge of the Sea, through the Eye-vane and the Object-glass, and in the direction of the Vertical or Azimuth, the Object is in; then move the Index from you, till you see the Image of the Object through the open part of the Glass, appear with its upper or lower Limb to join the Sea; and then lean your Instrument towards the right and towards the left, and you will see the Object appear to describe the Arch of a Circle, and when the Plane of the Instrument is perpendicular to the Horizon, the Image will appear to be the lowest, and in that position only the Object and Horizon should appear to join; on both sides of this Vertical Position, the Image will appear to rise above the Horizon.

Note. There are three Dark Glasses, which are to be used as Occasion requires. When the Object is too bright for the eye, either one or any two of them, may be put

* An Arch divided into each 10', with a Nonius which contains 30 Divisions, will shew each 20":

Thus, With 30) 10' or 600" (20" each
with 40) ——— 600 (15" each
with 60) ——— 600 (10" each

put down, so that the rays which pass from the Index Speculum to the Object-glass, may pass through one or two of them. When you observe the Distance of the Moon from the Sun or Star, put down one or two of the Dark Glasses, so as to make the more luminous Object to appear as near as possible, of the same lustre with the other Object, but not to make it less luminous than the other, because the want of light will make the Observation doubtful, and generally erroneous.

Suppose the Meridian Altitude of the Sun's lower edge observed $61^{\circ} 20' S.$ the upper edge $61^{\circ} 53' S.$ when the Declination was $17^{\circ} 15' N.$ what is the Latitude?

By Tab. 2. p. 6. Sea-officers Companion.

L. L. Denotes the Lower Limb of the Sun, and U. L. its Upper. P. D. Polar Distance. Z. D. Zenith Distance.

To the Alt. of L. L. $61^{\circ} 20'$		Apt. Alt. $61^{\circ} 53'$		for $\frac{1}{2}$ Diam. 16
Add for $\frac{1}{2}$ Diam. Dip. and Refract. $11\frac{1}{2}$		Subt. $20\frac{1}{2}$		
				Dip. 4
True Altitude by observation,	$61 \quad 31\frac{3}{4}S.$	$61 \quad 32\frac{1}{2}$		Ref $0\frac{1}{2}$
Zen. Dist.	$28 \quad 28\frac{1}{2}S.$	$61 \quad 32\frac{1}{2}$		
Declin.	$17 \quad 15N.$			Sum $20\frac{1}{4}$
		Mean $61 \quad 32\frac{1}{4}$		
By book as above, p. 14. Lat.	$45 \quad 43\frac{1}{2}N.$			

Ex. 2. Suppose Merid. Alt. of L. L. $46^{\circ} 26'$
of U. L. $47 \quad 00$

$\odot$'s centre $46 \quad 43$
Zen. Dist. $43 \quad 17 N.$
Declin. $17 \quad 23 N.$

Lat. $25 \quad 54 S.$

To Observe the Altitude of a Star.

Bring the Index to 0, and look through the Eye-vane and the Object-glass, at the Star, and if the Star be faint, or of the second or third magnitude, move the Sextant towards the left, till you see it reflected from the Speculum part of the Glass, and then move the Index by your left hand gradually from you, and lower the direction of your view, and you will see the image of the Star, which you must endeavour to keep on that part of the Glass, till you have brought it down to the Horizon, that is, to appear in a line with it.

In bringing the image of a Star down, which had little lustre, or those which had great altitudes, I used to turn the Eye vane edge-ways, and look over the Vane with both eyes open, and when I had got the image of the Star near the Horizon, it would appear faint, notwithstanding which I could by this means generally see when the Image was in a line of coincidence with the Horizon.

N. B. In the eye-vane of some Sextants and Octants, there are two sight-holes, the lower one is adapted for the Speculum part of the Object-glass, and the upper hole to the open part of the glass: But some of these instruments have only one sight hole which is adapted to the open part of the Glass, adjacent to the Speculum part.

Of the Manner of making Observations for determining the Longitude at Sea.

By the Nautical Ephemeris you may see the proper times for observing the distance of the Sun and Moon, also for the Moon and Stars, with their computed distance for each month, day, and for every three hours of the day. Having well adjusted your Sextant, and by the Ephemeris having found the distance of the objects nearly, that is within 20 or 30', set the index to that distance, and observe.

If the Sun be west of the Moon, or the Moon west of the Star, then the Sextant must be held in position of the plane passing through the objects to be observed, with its head towards the West, its Arch towards the East, and its face upwards; and that if the objects be not above 45 or 50° high, you may stand so as to look through the Eye-vane and Object-glass, at the less luminous object, (whether Moon or Star) and move the Sextant as you do when observing an Altitude, till you see the image of the other object in the open part of the Glass and then move the index by its assistant finger screw, till you make the coincidence of the edges of the objects.

When these objects are very high, it will be the easiest and best method to lay yourself down upon the deck with something under your head and shoulders, so as to give you a good position; by which you will find great advantage.

Some Sextants have handles to hold them by, fixed across from side to side; in many positions the handle will be of no service, as you will soon find by holding it, your arm will be cramped, which will oblige you to desist, and to try some other method. I have found that the best method is to hold it with your right hand by the brass foot, which is fixed under its head in some sextants; and your left hand applied to the arch, and the index assistant-screw, you will find it necessary to support the arch end, by the head of that assistant screw.

Note. When the luminous object is East of the other, then you must turn the face or fore-side of the Sextant downwards, by applying your right hand to the arch and the assistant screw, and your left hand at the upper part of the head.

Remark. That it frequently happens when the index is moved 30, 40, or 50° or more on the arch, that the index-glass loses its perpendicular position, by which both the object and its image will appear, and when this happens the observation will be defective. The method of adjustment and rectification will be shewn in a future publication,* as will also the defects and rectification of the telescopes.

In the Year 1761 I made the following Observations

February 21st. in the Prince Henry Indiaman, I observed

The Meridian Altitude of the L. L. ☉ 79° 28'

For ☉'s $\frac{1}{2}$ Diam. and dip. add 12

True Merid. Alt. 79 40

Z. D. or Zenith dist. 10 20 S.

Declin. 10 20 S.

Lat. 0 00

* In the second Part of the Sea Officers Companion.

August 5, 1761. On board the Oxford Indiaman I observed the Sun in my Zenith, which gave me much pleasure; my observing, what I wished for the foregoing day, the great velocity of the Sun in Azimuth, when it was near the Meridian.

The Day wherein I hoped to see the Sun pass the Zenith was remarkably fine, with a moderate gale, by which we made about four knots, or four miles an hour, the weather warm but not hot, which generally is the case, where the sun passes their Zenith at Sea.

About eleven I took my Octant, and went upon the poop, and stood where my horizon was 5' depressed. I tried the adjustments of the octant, which being right, I took the altitude of the sun, and at small intervals of time I repeated taking its altitudes and so continued, as the sun increased in altitude 15' in 1' of time, till I had got 88° altitude. I then observed continually in order to keep the coincidence of the horizon and Sun's image, as near as possible, by moving the Index gradually, and keeping the Octant in a vertical position, by which, and moving myself towards the right and towards the left, I soon found which way the Sun tended.

In order to find whether the sun moved in azimuth towards the meridian, on the North or South of my Zenith, at about half a minute before noon, I found it inclined towards the South. I therefore moved myself towards the right, turning round on my left heel, till I had made about one-third of a revolution; being then fully satisfied that I had got the true meridian altitude; I then turned round to observe to the Northward, when I found the North edge of the sun's image to appear more than half its diameter above the horizon.

The merid. alt. of the $\odot$'s L. L. was $89^{\circ} 41' S.$

+ $\frac{1}{2}$ diam 16' — 5' the dip. is + 11

True mer. alt. observed $89 \quad 52$

Ze. Dist. 0 8 S.

Decl. 16 52 N.

Lat. in 17 0 N.

The point of the surface of the sun, which passed the Zenith was 8' N. from its center; therefore the southern edge, when upon the meridian, was 16' nearer the horizon, than the northern edge or limb was to the North horizon.

Remark. That the nicety of these kind of Observations requires both judgment and care in making them, otherwise a very considerable error may be made.

A Table to turn Time into Degrees, Minutes and Seconds of the Equator. Also to convert Longitude of the Equator into Time.

Time	Lon. of the Equa.	Ti.	Lon. of the Equa.	Lon.	Time
		h.			h. m.
1	0 1	1	15°	20°	1 20
11	1 11	2	30	30	2 —
1	0 15	3	45	40	2 40
2	0 30	4	60	50	3 20
3	0 45	5	75	60	4 —
4	1 00	6	90	70	4 40
5	1 15	7	105	80	5 20
6	1 30	8	120	90	6 —
7	1 45	9	135	100	6 40
8	2 00	10	150	110	7 20
9	2 15	11	165	120	8 —
10	2 30	12	180	130	8 40
11	2 45	13	195	140	9 20
12	3 00	14	210	150	10 —
13	3 15	15	225	160	10 40
14	3 30	16	240	170	11 20
15	3 45	17	255	180	12 —
16	4 —	18	270	190	12 40
17	4 15	19	285	200	13 20
18	4 30	20	300	210	14 —
19	4 45	21	315	220	14 40
20	5 —	22	330	230	15 20
		23	345	240	16 —
		24	360	250	16 40
25	6 15			260	17 20
30	7 30			270	18 —
35	8 45			280	18 40
40	10 —			290	19 20
45	11 15			300	20 —
50	12 30			310	20 40
55	13 45			320	21 20
60	15 —			330	22 —
65	16 15			340	22 40
70	17 30			350	23 20
75	18 45			360	24 —
80	20 —				
85	21 15				
90	22 30				
95	23 45				
100	25 —				

Lon for Longitude
M. Minutes
S. Seconds
Equa. for Equator.

1 M. in time, is 15 M. of the Equator.
1" — is 15" of ditto.

A Table of the appt. Increase of the Semi diameter of the Moon at diff. Altitudes.

D. Ap Alt.	D. H 54'	Par. ^x 62'	Add to Horizontal Semidiameter, of the Moon.
5°	1"	1"	
8	2	2½	
12	3	4	
16	4	5	
20	5	6	
24	6	7	
26	6	8	
30	7	9	
34	8	10	
40	9	12	
44	10	13	
48	10	14	
52	11	15	
58	12	16	
65	13	17	
74	14	18	
85	15	19	
90	15	20	

Lon. Min.	Time M. S.	Lon. Min.	Time M. S.
1	4	20	1 20
2	8	21	1 24
3	12	22	1 28
4	16	23	1 32
5	20	24	1 36
6	24	25	1 40
7	28	26	1 44
8	32	27	1 48
9	36	28	1 52
10	40	29	1 56
11	44	30	2 00
12	48	31	2 4
13	52	32	2 8
14	56	33	2 10
15	M. 60	34	2 16
16	1 4	35	2 20
17	1 8	36	2 24
18	1 12	37	2 28
19	1 16	38	2 32

O F T H E
M E T H O D.



FOR DETERMINING THE

LONGITUDE at SEA.

BEING provided with a good Octant or Sextant, which has a Telescope and Moon Glasses, adapted to darken the Moon's Light, so as to make it nearly equal with that of the Star, by which the Distance is to be taken at the Limb of the Moon, or in Contact with her full Limb, by Reflection.

I have not seen one of those Instruments, out of the great Number of the many different Makers, that was complete in that respect.

1. The many different Circumstances which happen respecting these Observations, and the different Degrees of Light of the Moon and the Stars; by which many Observations prove abortive. I have, by repeated Trials, at last, got over this Obstacle.

2. There is another Impediment; which is, the Light of the Moon that falls on the Eye, when you are observing the Distance of her from Stars that do not exceed 50 deg. This Imperfection I have also taken off, or provided against.

3. It frequently happens, that the Distance of the Moon and Star can be observed when neither the Altitude of the Moon or Star can be taken; in which case, the Time being well ascertained, their Altitudes may be computed.

To find the apparent Time of an Observation, is a material Circumstance; and it frequently happens that you must trust to the going of your Watch for some Hours before or after the Time that you observe the Distance; especially in the Night, when you observe the Distance of the Moon and Star.

The proper Times of the Day for taking the Altitudes of the Sun, in order to find the true Time very near, is in the Fore or Afternoon, when the Bearing of the Sun is between five and eight Points from the Meridian, and the nearer to the prime Vertical, or East and West, the better; because in these Positions he rises and falls the quickest.

The Method is to take two or three Altitudes of the Sun, and to note the Times. These Altitudes should be taken at two, three or four Minutes after each other; then take the Mean. To take the Mean, is to add the Hours, Minutes and Seconds together, and to divide the Sum by the Number of the Times of Observations; the Result will be the Mean or Middle Time: and the like of Altitudes and Distances; then compute the Time by the following general Canon.

From half the Sum of the Co-lat. polar Distance and Co-alt. take the Co-lat. and polar Distance separately, and note the Remainders; then to the Sine Co-ar. of the Co-lat. and polar Distance, add the Sines of the two Remainders; the half of the Sum of these Sines will be the Sine of half the Angle of the Time before or after Noon.

At the Time the Distance of the Sun and Moon is observed, their Altitudes are generally taken by two Assistants, and there should be three or four Altitudes of each taken and as many Distances at the same Times; and these Observations should be made at four, five or six Minutes after each other; then reduce the several Times, the Altitudes of the Moon and them of the Sun or Star; as also the Distances into one Observation of Time, one Altitude of each Object, and one Distance, by finding the Mean of each; and then reduce the mean Time of the Observation by the Watch, to the true Time of the Observation, by adding or subtracting what the Watch was too fast or too slow.

To calculate the Altitude of the Sun, Moon or Star.

Having given the Latitude of the Place, the Declination and the Time, the Altitude may be found as follows:

First, For the Altitude of the Sun: Reduce the Hours, Minutes and Seconds of Time, before or after Noon, into Degrees, Minutes and Seconds, which will be the Angle of Time. Thus, the Minutes of Time divided by 4, give Degrees; and the Seconds of Time divided by 4, give Minutes; and if 1, 2 or 3 Minutes or Seconds remain, they will produce 15, 20, or 45 Minutes or Seconds for the angle of Time: For 1 Hour of Time corresponds with 15° of terrestrial Motion of the Equator.

General Canons for finding the Altitude of the Sun, Moon or Star.

1. $R : \text{cs of the angle of Time} :: \text{ct of the Latitude} : \text{the t. of the 4th arc.}$

From the polar Distance take the 4th arc, and the 5th arc will remain.

2. $\text{cs, 4th arc} : \text{cs, 5th arc} :: \text{s, lat.} : \text{s, true alt.}$ From the true Altitude of the Moon, take the Difference between the Parallax of her Altitude and the Refraction, the Remainder will be her apparent Altitude; but to the true Altitude of the Sun or Star, add the Refraction; the Sum will be the apparent Altitude.

Note, When the Altitude of a Star is to be found, the first Thing to be done is to find its right Ascension at the Time of the Observation. The following Table shews the right Ascension and Declination of such Stars as are used in the Observations for determining the Longitude at Sea.

Jan. 1. 1775.

	Right Ascension in Deg.	Right Ascension in Time.	Annual Var.	Declination.	Annual Var.
	Deg. mi. sec.	H. m. s.	Sec.	D. m. s.	Sec.
1. Arietis, the 5th * in Aries	28 37 59	1 54 32	3.337	22 23 23.6	+17.64
2. Aldebaran, the S. eye of the Bull	65 45 28	4 23 2	3.427	16 2 24.7	+8.32
3. Pollux, the Southern Twin	112 53 8	7 31 32½	3.751	28 33 7.37	-7.72
4. Regulus, or Cor. Leonis	149 5 41.5	9 56 23	3.240	13 3 32.2	-7.17
5. Spica Virginis	198 20 33.2	13 13 22.2	3.151	9 58 48.8	+18.97
6. Antares, Cor. Scorpio	243 54 44.7	16 15 39	3.661	25 54 47.4	+8.89
7. Atair. mid. * of Aquila	294 56 53.8	19 39 47.6	2.903	8 17 11	+8.40
8. Capric. or Capricorni	301 59 16.4	20 7 57.	3.353	15 29 50.2	-10.60
9. Fomalhaut	341 17 41.	22 45 10.7	3.378	30 48 29.4	-18.97
10. Pegasi. Markab	343 23 33.7	22 53 34.2	2.983	13 59 54	+19.20

To find the Angle of Time contained between the Meridian the Star is upon at the Time of Observation and the Meridian of the Place.

From the right Ascension of the Star take the right Ascension of the Sun at the Time of the Observation (adding 24 h. to the Star's right Ascension when it is less than the Sun's,) the Remainder will be the Time of the Star's Passage over the Meridian, from which take the Time of Observation; or from the Time of Observation take the Time of the Star's Passage over the Meridian, and the Difference will be the Time the Meridian of the Star, is to or from the Meridian of the Place; which convert into Degrees, &c.

Remark 1. The Times of Observations made in the Forenoon, are to be reckoned from the Noon of the foregoing Day.

2. When the Place of Observation is supposed or assumed to be East of the Meridian of Greenwich; then, from the Time of Observation, subtract 4 Minutes of Time for each Degree of Longitude; but for West Longitude add, and you will have the Time at Greenwich; to which Meridian the Tables of Time, Right Ascension and Declination, and the Distances of the Sun, Moon, and Stars are calculated.

3. When the Time of Observation is greater than that of the Passage of the Star over the Meridian, the Star has passed the Meridian; but when it is less, it has not passed

4. To make all Observations of the distances of the moon and star, at the west limb of the moon from change to full; but after full moon, make them on the east limb, or on the left side of her.

5. When a telescope is used which inverts, you must observe the star on the contrary side to appearance without the Telescope.

6. From change to full moon, add half her diameter to the distance of the stars observed west of her; but subtract half her diameter from the distance of stars east of her: after full moon use the contrary. //

EXAMPLE

To find the Angle of Time, contained between the Meridian the Moon is upon at the Time of Observation, and the Meridian of the Place.

Reduce the Time of Observation to that at the Meridian of Greenwich; and find the right Ascension of the Moon to that Time, in Degrees and Minutes, by the nautical Ephemeris, which convert into Time, either by the Table, p. 6. 7. and 8. of requisite Tables for finding the Longitude, or by multiplying the Degrees of right Ascension by 4 for Minutes of Time, and the Minutes of right Ascension by 4 for Seconds of Time; then if the right Ascension of the Sun in Time, reduced to the Time of the Observation at the Meridian of Greenwich, be greater than that of the Moon, add 24 H. to the Moon's, and take the Sun's right Ascension from the Sum, the Remainder will be the Time that the present Place of the Moon has passed, or will pass, the Meridian, after the Place of the Sun; and if this Remainder of Time be less than the Time of Observation, the Moon has passed the Meridian; but if it be greater, the Moon has not passed the Meridian: the Difference will be the Time the Meridian of the Moon is to or from the Meridian of the Place; which convert into Degrees and Minutes, and it will be the Angle of Time.

Note, That the right Ascension of the Sun taken from the Moon's, gives the Time of the present Place of the Passage of the Moon over the Meridian, after the Noon of the foregoing Day; from which Noon the Time of the Observation must be reckoned, as in the Example following.

E X A M P L E I.

The 16th of September 1772, the Distance of the Moon and Pegasi was observed, at 10 h. 7 m. at London: What were the Angles of Time for computing the Altitudes of the Moon and of the Star in respect of the Meridian.

	<i>H. m. sec.</i>		<i>Deg. m.</i>
*'s R. Ascen. -	22 53 28	☽'s R. Af. at Noon	41 8
☉'s ditto -	11 39 48	For 10 h. 7 m. add	5 3½
*'s passage over Mer.	11 13 40	☽'s true R. Ascen.	46 11½ = 3 4 46
Time of Observation	10 7 10 p. m.		+ 24 0 0
* to Meridian -	1 6 30	Sum	27 4 46
Which gives < of Ti.	16 deg. 37½ m.	☉'s R. Ascen.	11 39 48
		Passage of ☽'s pl. over Meridian	15 24 58
		Time of Observation	10 7 10
		☽ to Meridian	5 17 48
		Which gives the < of Ti.	79 deg. 33 m.

EXAMPLE II. September the 20th, at 8 h. 50. a. m. Dist. of ☉. and ☽ observed
to find the $\angle$ of Time for ☽'s Altitude.

	Deg.	m.	
☽'s R. Ascen. at Noon	92	1	
For 3 h. 10 m. deduct	1	40½	
True R. Af. at the Time of Obser.	90	20½	
			<i>b. m. f.</i>
			6 1 22
			+24 0 0
			Sum
			30 1 22
☉ R. Ascen.	11	52	10
Passage of ☽ over Meridian	18	9	12
Time of Observation	20	50	0
Before the Obs. the Moon passed the Meridian	2	40	48
Which gives the $\angle$ of Time	40	deg.	12 m.

EXAMPLE III.

	Deg.	m.	f.
September the 19th, ☽'s true R. A. at Obser.	84	59	12
Ditto in Time	5	39	57
			+24
☉'s R. Ascen.	11	50	21
Passage of ☽'s pl. over Merid.	17	49	36
Time of Observation	11	23	45
☽ to Mer. $\angle$ of Time	96	deg.	18 m. East, = 6 25 51
Supplement	83	— 42	— = 5 34 9

EXAMPLE IV.

In Long. 92° E. the Ti. of Obser. was 16 h. 15 m. 10 sec. p. m. the 16th. of Sept
For 92° E. = 6 8 sub.

Time at Greenwich	10	7	10 as in Example I.
			<i>b. m. f.</i>
*'s passage over Meridian	11	13	40
Time of Observation	16	15	10
* Past Meridian	5	1 30	= 75° 22½' $\angle$ Time
Passage of ☽'s pl. over Merid.	15h.	24m.	58f.
Time of Observation	16	15	10
☽'s pl. past merid.	12°	33'	= 0 50 12

September 20d. 1h. 30m observed Distance of ☉ and ☾

For 70° E. sub. 4 40

Sept. 19 20 50 Time at Greenwich; to which
Time the R. A. of the ☉ and ☾ must be found.—Also the
☾'s Hor. Parx. Diam and Distance, by Eph.

E X A M P L E V.

H. m.	D. m.	D. m.	D. m.
Oct. 21. at 0 10	Dist. of Sun and Moon 67 57	☾'s app. Alt. 21 13	☉ 27 29

H. m. sec.
☾'s Ri-asc. 9 28 24
+ 24 0 0

☉'s Ri-asc. 13 46 27 sub.

Oct. 20th. at 19 41 57 p. m. the Pl. of the ☾ passed Mer.
Time of Ob. 24 10 0

Or thus:

D. h m.
Oct. 20 19 42 p m.
is Oct. 21 4 18 bef N
Ti. of Ob. 0 10 p. m.
☾ past Mer. 4 28

☾ Past Mer. 4 28 3 = 67 deg. the $\angle$ of Time.
Note, $\angle$ Denotes Angle.

Having given the apparent Altitudes and Distance, to find the Difference of the Azimuths of the Sun and Moon, or Moon and Star.

G E N E R A L R U L E S.

Rule 1. To work by apparent Distance, and the apparent Zenith Distances.

From half the Sum of the apparent Distance, and the two Zenith Distances, take the Zenith Distances separately, and note the Remainders; then take the Sine Complement arithmetical of each Zenith Distance, and the Sines of the two Remainders; add the four logs together: and half the Sum will be the Sine of half the Angle of Azimuth.

Rule 2. To work by the true Zenith Distances.

R : t, of the lesser of the true Zenith Distances :: cs, of the Difference of Azimuth : the t, of the 4th arch. If the Difference of Azimuth be less than 90 deg. then from the greater true zenith Distance take the 4th Arch, and the remainder will be the 5th Arch; but if the difference of Azimuth exceeds 90 degrees, then to the 4th Arch add the greater true Zenith Distance, and the Sum will be the 5th Arch.

Note, When the 5th Arc is less than 90 deg. the reduced Distance will be less than 90; but when the 5th Arc exceeds 90 deg. the reduced Distance will be greater than 90 deg.*

Rule 3. As cs, 4th Arch : cs, 5th :: cs, less true Zenith Distance : cs, of the true or reduced Distance by Observation; which being done, find the Distance by the Ephemeris, at the Time of the Observation, reduced to the Time at Greenwich, and then,

Remark 1. When the Distance is increasing, and the observed Distance greater than that by the Ephemeris, the Longitude is West, but if it be less, it is East Longitude: which must be applied to the Longitude that you assumed the Ship to be in.

* By reduced Distance, is to be understood the true Distance by the Observation; or the observed distance cleared from the effect of Refraction and Parallax.

2. When the Distance is decreasing, and the observed Distance the greater, then the Longitude resulting from the Difference is East; but if it be less, the Longitude is West.

EXAMPLE I. To find the Longitude of the Place of Observation.

Ex. Sept. 20th 1772, at 8 50 am. *b. m.* Dist of Centers. ☉ apt. Alt. ☽ apt. Alt.

☽ s Park. of Alt. 40' 47" ⁰⁰
Refraction 1 1 07

☉ apt. Alt. 25 37
☽ apt. Alt. 43 39 30
Z D 64 23 Do. 46 20 30
Refraction + 2 — 29 30

True Z D 64 25 Do. 45 41 00

Apt. Distance 88° 5' 0"

☉'s Z D 64 23 0

☽'s Z D 46 20 30

The Sum 198 48 30

Half the Sum 99 24 15

Differences { 35 1 15
53 3 45

0 0449347

0 1405798

9 7588367

9 9027052

19 8470564

9 9235282 S of 56° 59' 10"
x 2

Dif. of Azimuth 113 58 20
Supt. 66 1 40

t, less tr. Z D 45° 41' = 10 0103601

cs, dif. of Az. { 113 58 20 } 9 6088401
66 1 40

t, of 4th Arc 22 35 30 = 9 6192002

gr. tr. Z D 64 25 00

cs, 4th. — 0 0346731

5th Arc 87 00 30 cs, 5th. — 8 7175932

cs, less tr. Z D 45 41 — 9 8442432

cs, true dist. by Observ. 87 44 10 = 8 5965095

tr. do by Ephemeris 87 39 8

Dif. 5 2 gives 2° 33' E.

Long in by Assumption 3° 0' W.

By Observation the Place is East of that Assumed 2 33 Sub.

Long. in by the Observation 0 27 W.

Note, the reduced distance by Lyon's Method is 87° 44' 9"

*To find the Parallax of the Moon in Altitude, and the Refraction, see Waddington's Sea Officer's Companion.



EXAMPLE II. To find the Longitude of the Place of Observation, when the Distance observed exceeds 90 Degrees.

1772, October the 19th, In the Latitude 51 Deg. 30m. N. Longitude, Assume 5 h. = 75 deg. W. where the mean of four Distances of the Sun and Moon was 89 Deg. 48m. 10sec., the Time 11h. 30m. am. at the place of Observation.
add 5 00 for W. Longitude

Time at Greenwich 4 30 p m.

Oct. 19, at No. D's R. Af. 114° 54' De. 16 8N. h. h.
At Midnight 121 38 — 14 58 If 12 req. 6° 44' -- 4½ -- 2° 31½ inc.
12 is to 1 10 -- 4½ -- 0 26 dec.
In 12 Hours the Dif. 6 44 and 1 10

In 4½h. the Increase + 2 31 Decr. -26
Gives the true R. A. 117 25 Decl. 15 42 N. ½ Diam. 15' 37" H. Par. 57' 20"
H. M. S. P. D. 74 18 of D
R. A. in Time = 7 49 40 Time of Observation 30' before Noon = 7° 30' the <
+ 24 — of Time for finding the Altitude of the Sun.
Sum 31 49 40 R:cs. < 7° 30' :: ct, 51° 30' t, of 4th Arc = 38° 15' 35"
Sun's R. Ascen. 13 39 35 D's polar Distance 100 21 36
cs, 4th A.:cs, 5th::s, Lat. S. Al. 27 48 | 5A=62 6 0
Dif. of R. A. 18 10 5
Ti. of Observa. 23 30 0 at the Ship.

D past Meridian 5 19 55 = 79d. 59m. the < of Ti. for finding the Alt. of the D
co. ar.

R : cs, < Ti. 79° 59' = 9,2403861	cs, 4th Arc 7° 52' 40" = 0,0041180
:: ct, Lat. 51 30 = 9,9006052	cs, 5th Arc 66 25 20 = 9,6020530
	:: s, Lat. 51 30 = 9,8935444
t, of 4th Arc 7° 52' 40" = 9,1409913	: S. true Alt. 18 25 20 = 9,4997154

D's po. Dist. 74 18 00
5th Arc 66 25 20
D's Par. of Alt. 54' 40" } 0° 51' 50"
Refraction 2 50 }

D's true Alt. 27° 48'
Refraction + 2

D's apparent Altitude 17 33 30
Apparent Z. D. 72 26 30
True Z. D. 71 34 40

appar. Alt. 27 50
Z. D. 62 10
True Z. D. 62 12

(17)

Apparent Dist. of the Limbs observed 89d. 48m. 10 sec. See foregoing page.

Half Diam. of the ☉

16

08

Half Diam. of the ☽

15

37

For ☽'s Alt. add

} See Nautical Ephem.

5 by table in p. 8, of the use of
the Sextant.

Apparent Distance of Centers 90 20 00

	H.	Deg.	Min.	Sec.
By the Ephemeris. The dist. at 3 p. m.	91	9	55	
at 6	89	38	38	

The Diff. in	3h.	is	1	31	17	
in	1 30'	is		45	39	sub. fr. D at 3h.

True dist. at	4 30 p. m.	90	24	16	by Eph.
---------------	------------	----	----	----	---------

The foregoing Particulars are the requisite Preparations for all the different Methods of Calculation.

I. R. WADDINGTON'S Method of computing the Longitude by Trigonometry.

October 19th, App. Dist. of the Centers 90° 20' 0"

☽'s apparent Z. Dist. 72 26 30—0,0207202

☉'s apparent Z. Dist. 62 10 0—0,0533957

9,8083309

224 56 30 | 9,8861782

112 28 15 |

19,7686250

40 01 45 | 9,8843125, s, of 50° 0' 35"

50 18 15 | × 2

Its double is the diff. of Azimuth	100 1 10
Supt.	79 58 50

II. R : t, 62d. 12m. — 10,2779915	The hly. Decr. of } 30° 26"
:: cs, Diff. Az. 100 1 10—9,2405053	
: t, of 4th Arc. 18 15 45—9,5184968	As 30° 26": 15° long.
Add the gr. Z. D. 71 34 40 as by rule II.	:: 28 59 : 14 17' W. long.
5th Arc 89 50 25	(as appears by remark 2, p. 15)
III. cs, 4th Arc 18 15 45—0,0224452	which added to the long, the
: cs, 5th Arc 89 50 25—7,4432421	ship was assumed to be in;
:: cs, less Z. D. 62 12 00—9,6687461	Viz. to 75° 00' w.
	add 14 17 w.
: cs, red. Dist 89 55 17—7,1366314	Ship's Long. 89 17 w.
Dist. by Eph. 90 24 16	
diff. 28 59	

Taken out at sight from
Gardiner's Logarithms.

2. Method by Prop. 1. Sherwin's Tables of versed Sines, See p. 38 of 3d Edit. having found their dif. of Azimuth, by the first Canon foregoing; or by Sherwin's Rule, p. 31, the angle at the Zenith: And having given the two sides, and contained angle, of the Spheric Triangle; to find the third side.

Log. Versed sine of the diff. of Az. Sup. $79^{\circ} 58' 50''$ — 9,9169893

Log. Sine of Sun's tr. Z. D. $62^{\circ} 12' 00''$ — 9,9467376

Log. Sine of Moon's tr. Z. D. $71^{\circ} 34' 40''$ — 9,9771534

No. to Log. is $6932,350$ — 9,8408803
 Nat. v. sine of $133^{\circ} 46' 40''$ } — 16918,632
 the sum of the sides }

Nat. versed $9986,282$ of $89^{\circ} 55' 17''$ the red. dist.
 for $9985,456$ — $89^{\circ} 55' 00''$

If 2908 give $60''$ then will 826 give $17''$

Dist. by Eph. at $3^h 0' - 91^{\circ} 9' 55''$ } By Art. 4, p. 154 of proportional Log. or
 Dist. by Obs. at $4 30 - 89^{\circ} 55' 17''$ } in the book of requisite tables.

Diff. $1 14 38$ prop. log. 3823
 Decr. of dist. in 3^h $1 31 17$ its ditto 2949

Diff. 874 gives $2^h 27' 11\frac{1}{2}''$
 The time of the preceding dist. by Eph. add $3 0 0$

True time of the Observation at Greenwich $5 27 11\frac{1}{2}$ p. m.
 True time of ditto at the ship bef. Noon $0 30 00$ a. m.

The time converted, } gives the Longitude $89^{\circ} 18' W.$ = $5 57 11\frac{1}{2}$
 By table, p. 8. }

I must recommend the Book of Logarithms, sold by Mr. Nourse in the Strand, which has the Tables of Sines and Tangents to every ten seconds. And the first and last 4° of the Quadrant, to each single second of the Sine, Cosine, Tangent and Co-tangent.—Quarto, bound in Calf and lettered, price £2. 7s. — Since the fourth Edition of Sherwin's Logarithms is worse than the third, and the fifth much worse than the fourth. — This once valuable Book is now of little use, owing to the bad management of the conductors.

Note, When the Index of the Log. of a Sine, Cosine, or versed Sine is 9, there will be four places of whole numbers in the natural number corresponding.

When the Index is 8 there will be 3 whole numbers,

7 — 2 ditto
 6 — 1 ditto
 5 — 0 all decimals.

In Sherwin's Tables, where the Radius of the Log. Sines is 10, the natural Number to it is 10000.

3. CALCULATION by Mr. DUNTHORN'S Method. [See Requisite Tables, p. 64 and 65, also the Appendix to the Nautical Eph. for the Year 1772, page 38.]

☉'s apparent alt. 27d. 50m. 0 sec.	☉'s True altitude 27° 48'
☽'s apparent alt. 17 33 30	☽'s True altitude 18 25 20
Difference 10 16 30 its Nat. cs. 9839,64	diff. 9 22 40
Observed Distance 90 20 — its Nat. cs. 58,18	
Supt. 89 40 —	
Because the distance exceeds 90° the Sum 9897,82 = 4,9955387	
Log. difference by Table II.	Sub. 19887
No. to Log. 98526,0	—4,9935500
Nat. cs. of Diff. of true alts. 9 22 40 98663,5	
This difference 137,5 is the Nat. cs. of 89° 55' 16"	
the reduced dist. by the Observation.	

4. CALCULATION by Mr. LYON'S METHOD. [See requisite Tables, p. 19 and 20 the Rules.]

By Table I. Large Sheet.

Agt. 27 Deg. under 17 Deg. is 0939 and under 18 Deg. is 0843
 Agt. 28 under 17 is 1000, and under 18 is 0939

1st Difference, gives 61 and 96

If 60' : 61' :: 50' : 51' for the Increase of greater Alt. } hence from 0939
 If 60 : 96 :: 53½ : 54 for the Decrease of lesser Alt. } take 3

Difference 3 No. to Log. 124" — 2,0936

Observed Distance	Deg. m. sec. 90 20 00	☽'s Hor. Parallax 57' 20" — 0,49680
Effect of Refraction	+ 2 4	Log. cofec. of 27.48 — 10,33125
		Log. fine of 90.22 — 9,99999
Dist. cleared of Refrac.	90 22 04	Propl. log. 1st Arc 26 45 — 0,82804
Effect of Parallax	— 26 52	
Reduced Distance	89 55 12	☽'s Hor. Parx. 57 20 — 0,49680
Which is the same as by the other		Log. cofec. of 18 22 30 — 10,50136
two Methods, nearly.		t, of 90 22 0 — 12,19384
		Pr. log. 2d Arc 0 0 7 — 3,19200

5. Calculation by the Method, from an amazing large Book of Tables, lately published.

Apt dist. 90° 20' D's alt. 17° 33½' ☉'s alt. 27° 50'.
Hor. Par.* 57 20

Under dist.	90°			Reduct.		Cor. Log.	Var.
D's alt.	17	⊙'s 27°	is	21' 58"	and	345	and 6
ditto	17	⊙'s 28	is	22 46	and	331	and 6
Change of red. for 1° ⊙'s alt.				+ 48	and	14	and 0
D's alt.	18°	⊙'s 27°	is	22 01	and	345	and 6
Change of red. for 1° D's alt.				+ 03	and	00	ard 0

Under dist. 91°

D's alt. 17° ☉'s 27° is $22' 12''$ and 340 and 0
For 1° of dist. change of red. $+ 14$ and 5 and 0

60' incr. of ☉'s alt is $+ 48''$ therefore 50' will increase $+ 40''$
of D's alt. is $+ 2$ and $33\frac{1}{2}$ will increase $+ 2$
of dist. is $+ 14$ and 20 will increase $+ 5$

The increase of altitudes and of dist. give the meridian of red. + 47

Also, if 60' decr. of corr. log. give for $1^\circ \odot$'s alt. 14 } then 50' will give 12
for 1° D 's alt. 0 } 33 will give 00
for 1° diff. 5 } 20 will give 02

The increase of altitudes and distance give the decrease of the corr. log. 14

From the correcting log. first found	345	Observed distance	90° 20' 00"
take the decrease of corr. log.	14	Reduction	21' 58"
		To which add	47
True correcting log.	331	and	2 2
☉'s Hor. Par. ^x	57' 20"	the sum	sub. 24 47
least ditto	53 00		
Par. log. of the excess	4 20 =	True dist. by obs. as before	89 55 13
	317		
The sum gives	2 2		
	648		

This method appears to me, long and tedious:

6. Method.—The Royal Astronomer's Rules and method of Calculation, [See the Appendix to the Nautical Ephemeris for the Year 1773, p. 2 to 18.]

7. Method,—Mr. G. Witchel's Rules and Method in said Appendix, p. 18 to 25.

A Table to convert the difference between the reduced distance and that by the Ephemeris, into Longitude of the Equator.



The hourly Increase or Decrease of Distance, being

26'	27'	28'	28½'	29'	29½'	30'	30½'	31'	31½'	32'	32½'	33'	°
0,08½	0,09	0,09½	0,09½	0,09½	0,10	0,10	0,10½	0,10½	0,10½	0,10½	0,11	0,11	5
0,17½	0,18	0,18½	0,19	0,19½	0,20	0,20	0,20½	0,20½	0,21	0,21½	0,21½	0,22	10
0,26	0,27	0,28	0,28½	0,29	0,29½	0,30	0,30½	0,31	0,31	0,32	0,32½	0,33	15
0,35	0,36	0,37½	0,38	0,38½	0,39½	0,40	0,40½	0,41½	0,42	0,43	0,43	0,44	20
0,43	0,45	0,46½	0,47½	0,48½	0,49½	0,50	0,50½	0,51½	0,52½	0,53½	0,54	0,55	25
0,52	0,54	0,56	0,57	0,58	0,59	1,00	1,01	1,02	1,03	1,04	1,05	1,06	30
1,01	1,03	1,05½	1,06	1,08	1,09	1,10	1,11	1,12	1,13½	1,15	1,16	1,17	35
1,10	1,12	1,14½	1,15½	1,17	1,18½	1,20	1,21½	1,23	1,24½	1,26	1,27	1,28	40
1,18	1,21	1,24	1,25	1,27	1,28½	1,30	1,31½	1,33	1,34½	1,36	1,37½	1,39	45
1,27	1,30	1,33½	1,34	1,36	1,38	1,40	1,41	1,43	1,45	1,46	1,48	1,50	50
1,35	1,39	1,42½	1,44	1,46	1,48	1,50	1,52	1,54	1,55	1,57	1,59	2,01	55
1,44	1,48	1,52	1,54	1,56	1,58	2,00	2,02	2,04	2,06	2,08	2,10	2,12	
2,01	2,06	2,11	2,13	2,15	2,17	2,20	2,22	2,25	2,27	2,29	2,32	2,34	10
2,19	2,24	2,29	2,32	2,35	2,37	2,40	2,43	2,46	2,48	2,50	2,52	2,56	20
2,36	2,42	2,48	2,51	2,54	2,57	3,00	3,03	3,07	3,09	3,11	3,14	3,18	30
2,53	3,00	3,07	3,10	3,13	3,16½	3,20	3,24	3,27	3,30	3,33	3,36	3,40	40
3,11	3,18	3,25	3,29	3,33	3,36½	3,40	3,44	3,48	3,52	3,54	3,58	3,02	50
3,28	3,36	3,44	3,48	3,52	3,56	4,00	4,04	4,08	4,12	4,16	4,20	4,24	
3,45	3,54	4,03	4,07	4,11	4,16	4,20	4,24	4,29	4,33	4,38	4,41½	4,46	10
4,03	4,12	4,21	4,26	4,30	4,36	4,40	4,45	4,50	4,54	4,59	5,03	5,08	20
4,20	4,30	4,40	4,45	4,50	4,55	5,00	5,05	5,10	5,15	5,20	5,25	5,30	30
4,37	4,48	4,59	5,04	5,09	5,15	5,20	5,25	5,31	5,36	5,41	5,46	5,52	40
4,55	5,06	5,17	5,23	5,29	5,34	5,40	5,46	5,51	5,57	6,02	6,08	6,14	50
5,12	5,24	5,36	5,42	5,48	5,54	6,00	6,06	6,13	6,18	6,24	6,30	6,36	
5,30	5,42	5,55	6,01	6,07	6,14	6,20	6,26	6,34	6,39	6,46	6,51½	6,58	10
5,47	6,00	6,13	6,20	6,27	6,34	6,40	6,47	6,54	7,00	7,07	7,13	7,20	20
6,04	6,18	6,32	6,39	6,46	6,53	7,00	7,07	7,14	7,21	7,29	7,35	7,42	30
6,21	6,36	6,51	6,58	7,15	7,13	7,20	7,27	7,34	7,41	7,49	7,56	8,04	40
6,39	6,54	7,09	7,17	7,35	7,33	7,40	7,47	7,55	8,02	8,10	8,18	8,26	50
6,56	7,12	7,28	7,36	7,44	7,52	8,00	8,08	8,16	8,24	8,32	8,40	8,48	
7,14	7,31	7,47	7,55	8,03	8,12	8,20	8,28	8,36	8,45	8,54	9,02	9,10	10
7,32	7,49	8,05	8,14	8,23	8,32	8,40	8,49	8,57	9,06	9,15	9,23	9,32	20
7,48	8,06	8,24	8,33	8,42	8,51	9,00	9,09	9,18	9,27	9,36	9,45	9,54	30
8,06	8,24	8,42	8,52	9,01	9,11	9,20	9,29	9,38	9,48	9,58	10,06	10,16	40
8,23	8,42	9,01	9,11	9,21	9,31	9,40	9,49	9,59	10,09	10,19	10,28	10,38	50
8,40	9,00	9,20	9,30	9,40	9,50	10,00	10,10	10,20	10,30	10,40	10,50	11,00	
10,24	10,48	11,12	11,24	11,36	11,48	12,00	12,12	12,26	12,36	12,48	13,00	13,12	6
12,08	12,36	13,04	13,18	13,32	13,46	14,00	14,14	14,28	14,42	14,58	15,10	15,24	7
13,52	14,24	14,56	15,12	15,28	15,44	16,00	16,16	16,32	16,48	17, 4	17,20	17,36	8

For the Seconds of hourly Motion above Minutes, take the proportional parts of the diff. of the Seconds in the Column.

The use of the foregoing Table, is to reduce the difference between the reduced Distance of the Observation and that by the Ephemeris into Longitude.

Enter the Table with the hourly increase or decrease of Distance, or the nearest to it, at the head of the Table (the hourly Difference is obtained from the Ephemeris) and in the Column under it, find the Minutes and Seconds, or the nearest thereto, of the difference between the reduced Distance and that by the Ephemeris at the Time of the Observation, and in the right hand Column you will have the Longitude corresponding in the same Horizontal Line; which must be added to, or subtracted from the Longitude you assumed the ship to be in, as directed in the first or second Remark, p. 14 and 15.

Ex. 1. Suppose the difference $5' 02''$ as in p. 15, and the hourly difference of distance of the Sun and Moon $29' 27''$, under $29\frac{1}{2}$ is $4' 55''$ and $5' 15''$, by which the Longitude appears at sight to be $2^{\circ} 33'$

Ex. 2. If the difference of Distance be $28' 59''$ as in p. 17, and the hourly Decrease of Dist. $30' 26''$, to find the corresponding Longitude, under $30\frac{1}{2}$ I find $9' 29''$ and $9' 49''$, one of them is less and the other more than $\frac{1}{3}$ of $28' 59''$, which is $9' 40''$ —, and for which may be taken $4^{\circ} 45\frac{1}{2}'$, because the Increase of the Seconds is $20''$, under $30\frac{1}{2}$, which corresponds with $10'$ increase of Longitude (in Longitude Column) therefore say, as $20'' : 10' : : 11''$ the excess of $9' 40''$ above $9' 29'' : 5' 30''$: Hence the Longitude corresponding to $9' 40''$ is $4^{\circ} 45\frac{1}{2}'$ which multiplied by the No. that $28' 59''$ was divided by, viz.

3

gives the Longitude answering to $28' 59'' = 14^{\circ} 16\frac{1}{2}'$

and the like of any other.

Remark. That all Observations are to be computed according to the true time at the Ship or Place; but the Requisites that are to be taken from the Ephemeris, must be found by the time of Observation reduced to the Meridian of Greenwich, by Remark 2, p. 11.

	Latitude	Longitude	
		in time	in degree
Greenwich Observatory	$51^{\circ} 28' 39''$ N.	$0^h 0' 00''$	$0^{\circ} 00'$
London, St. Paul's	$51^{\circ} 30' 45''$ N.	$0 0 20$	$0 05$ W.
Portsmouth, Church	$50^{\circ} 48' 36''$ N.	$0 4 20$	$1 05$ W.
The Lizard Point	$49^{\circ} 57' 30''$ N.	$0 21 20$	$5 20$ W.
I. St. Mary's Scilly	$49^{\circ} 58' 00''$ N.	$0 27 00$	$6 45$ W.
Gilston's Rocks, S. W. from I. St. Mary's, 9 Miles, Sr Cloudsley Shovel was lost in Oct. 1707, on these rocks	$49^{\circ} 52' 00''$ N.	$0 27 43$	$6 55$ W.
Paris, at the Observatory	$48^{\circ} 50' 14''$ N.	$0 9 10$	$2 17\frac{1}{2}$ E.
Petersburgh, Russia	$59^{\circ} 56' 00''$ N.	$2 1 29$	$30 22$ E.
Stockholm, Sweden	$59^{\circ} 20' 30''$ N.	$1 12 17$	$18 04$ E.
Port Royal, Jamaica	$17^{\circ} 53' 00''$ N.	$5 7 0$	$76 45$ W.
C. Good Hope, the Point	$34^{\circ} 29' 00''$ S.	$1 13 31$	$18 23$ E.
Madras —	$13^{\circ} 18' 00''$ N.	$5 20 10$	$80 02$ E.
Pico Teneriff	$28^{\circ} 13' 00''$ N.	$1 6 8$	$16 32$ W.

Of REFRACTION,

Or the bending of the Rays of Light, as they pass through the Atmosphere of the Earth; that is, as they pass through that part of the Air, which receives Vapours and Exhalations.

Def. 1. By the Rays of Light are to be understood their least parts, and those as well successive in the same lines, as contemporary in several lines. For it is manifest that Light consists of parts both successive and contemporary: Rays of Light may be considered to be lines reaching from the luminous body to the body illuminated, and the Refraction of those Rays to be the bending or breaking of those lines in their passing out of one medium into another.

2. By the Eclipses of Jupiter's Satellites is proved, that Light is propagated in time, and is about seven minutes of time in passing from the Sun to the Earth.

3. The Angle of incidence, is that Angle which the line described by the incident Ray contains with the perpendicular to the reflecting or refracting Surface at the point of incidence.

4. The Angle of Reflection or Refraction, is the Angle which the Line described by the reflected or refracted Ray, makes with the perpendicular; supposed to be drawn, to the reflecting or refracting Surface, at the point of incidence, and in uniform Mediums it is bent at its entering into the medium, and then proceeds in a right line; but in passing through Mediums which increase or decrease in density, the Angle of Refraction at any point, is the Angle contained between the perpendicular drawn from that point, and the Ray from thence proceeding; and this Angle decreases as the Ray passes through increasing Mediums; but the Angle increases, as it passes through decreasing Mediums.

5. The Sines of Incidence, Reflection and Refraction, are the Sines of the Angles of Incidence, Reflection, and Refraction: as the angles ABD , DBC and EBF in fig. 1.

A X I O M S.

1. The Angles of Reflection and Refraction, lie in one and the same plane, with the Angle of Incidence.

2. The Angle of Reflection is equal to the Angle of Incidence.

3. If the Refracted Ray be returned directly back, that is, if it be reflected perpendicularly, it shall be refracted into the line before described by the incident Ray, to the point of Incidence.

4. Refraction out of the rarer Medium into the denser, is made towards the perpendicular, that is, the Angle of Refraction is less than the Angle of Incidence; but Refraction out of a denser into a rarer Medium, is made from the perpendicular, *Dif. 4.* By fig. 1. AD is the sine of incidence $= DC$ the sine of Reflection, and EF in the sine of Refraction.

If the Proportion or Ratio of the Sine of Incidence to that of Refraction, be known, in any one inclination of the incident Ray, it will also be known in all other inclinations: Thus if the Refraction be made out of Air into Water, the Sine of Incidence of the red light, is to the Sine of its Refraction into the Water as 4 to 3. Thus, $AD = aG$, and $aG : FE :: 4 : 3$. If out of Air into Glass, the Sines are as 17 to 11. In Rays of Light, of other colours, the Sines have other proportions; but the difference is so little that it needs seldom to be considered. [See Sir Is. Newton's Optics.]

5. A Ray of Light in passing through a Medium which increases in density, makes the Ray bend toward the denser parts continually as it passes through it; by which all Rays will appear as if they had proceeded from other points than they really did. The Sun, Moon and Stars and all objects on the earth, appear higher by Refraction, than they are; the Angle or quantity of Refraction, at different, apparent Altitudes, in a middle state of the Air, is in the Table of Refraction.

Fig. 4 Suppose B E D to represent the Surface of the Hemisphere of the Earth, and A L G H the upper surface of the Atmosphere; b p, a Ray of Light which enters into the Atmosphere at b, and passes to F, in the Curve continually bending towards the perpendicular p C, and at F, it is the deepest immersed; from F it proceeds to L; quits the Air, and is refracted from the perpendicular L O, into the right line L M; and the power of Refraction at L, will be double to the Refraction at F, because the Ray in its passage from b to F, passed through the like Medium as it did from F to L, and in course, the effects will be equal.

Suppose a Ray of Light proceeding from the upper edge of the Sun at a, enters the Atmosphere at I, and is refracted from its directions I r, to E, the place of an Observer, who will see the Sun's upper Edge in direction of the Line of the sensible Horizon E d, in which it entered the Eye. The Horizontal Refraction is the greatest, and it varies from 29 to 37 Minutes in the Latitude of London; consequently when the Sun appears in the Horizon, * he is 33 Minutes below it by a mean Refraction; and in greater Latitudes something more, the Atmosphere being more dense. Let m represent the place of an Observer on the top of a Mountain, m l, his visible, and m n, his true Horizons, the visible Horizon at l, will appear higher than it is, occasioned by the Refraction of the Rays coming from thence to the Eye, from a denser to a rarer Medium; for by Axiom 5, and Def. 4, the perpendicular to the Refracting Surface is S e, and the point of Incidence is at S, which point will appear to be lifted up, by the Refraction of the Ray S m; it being bent from the perpendicular; this Refraction added to the apparent Horizontal Refraction, of the Sun or Stars, gives the true Refraction as determined by calculations. When it is lessened by the Sun's Horizontal parallax, the mean parallax of the Sun being 8,75 seconds, as determined from the Observations of the Transits of Venus over the Sun in the Years 1761 and 1769, The Horizontal Refractions must be the greatest, because the Rays in that Position pass through the greatest space of the Atmosphere, also through the greatest quantity of vapour. The Angle n m l, is the depression of the visible Horizon, below the true Horizon; and the rational Horizon is that which passes through the center of the Earth, as A H, respecting E, parallel to the true Horizon h d.

Suppose an observer, on shore, with an Astronomical quadrant, observes the lower edge of the Sun's limb to be 40' 20" above the surface of the sea; the altitude of the telescope 20 feet, higher than the sea; when the diam. of the Sun is 32' 30", and his Horizontal parallax 9", the Horizontal refraction 33'; to find the true Zenith distance of the Sun. Thus, the appt. alt.

above the vis. horizon 40' 20" | L. L + 16' 15" — 26' 57" Ref.
The diff. between the quantities 14 49 | H. P. + 0 9 — 4 16 for 20 ft. high

True alt. of Sun's center, }	25 31	+ 16 24	— 31 13
above the Hor.			
Z. Dist.	64 29	their diff. is 14 49	

* Note, The true Horizon of any place, is a Tangent to the Curve of the Earth's Surface at that place: which is 90° from the Zenith in every position and place.

Art. 1. The rays of light which fall obliquely on a medium, in passing through it, if the medium be uniform, are only bent at their entering into, and coming out of it; but in passing through mediums, which gradually increase or decrease (as the Atmosphere) the rays at entering in, and passing through it, are gradually bent, so long as the medium increases through which they pass; and they will enter the eye, refracted the same quantity, as if the medium had been uniform, and of the same density as that where they enter the eye.

Remark 1. The quantity of refraction is the same, whether the rays pass through a mile or an inch of it, in the same medium, with that near the eye. And because the last inch of Atmosphere; before the ray enters the eye, gives the quantity of its refraction; therefore by passing through the whole Atmosphere the quantity of refraction is not increased. For Example,

Suppose the Atmosphere of the earth (through which an oblique ray passes to the eye) to be divided into three mediums; the first medium the ray passes through, suppose it to be refracted 1, the second medium double in density to the first; and the third medium treble to the first; then I say the refraction in passing through the first being one, in passing through the second Medium it will be refracted $1+1=2$ by both these mediums; and in passing through the third Medium it will be refracted $1+1+1=3$, by all the three mediums: because the succeeding mediums have a refractive power in proportion to their density, Q E D.

Remark 2. Since the rays of light are the most refracted in that part of the Atmosphere which is the most dense; it may happen in many circumstances, that the rays may be reverted before they come to the eye; for instance, if the air round a Telescope, through which a person is observing the altitude of a Star, be rarer than it is at some distance from the Telescope; by the foregoing principles, the curve of the rays will be inflected before they enter the Telescope, and in course the Altitude of the Star will appear less than it would have done, provided the medium within and without the place of observation had been the same. For this reason, and the Methods used in many Observatories; it is evident, that no great accuracy can possibly be drawn from their Observations, save the Meridian ones.

N. B. That Observatories which are built on the summits of hills; and those in valleys are both liable to many inconveniences, which those that Stand on Spacious Planes are not subject to.

Sir Is. Newton's Optics, Prop. 7. The perfection of Telescopes is impeded by the different refrangibility of the Rays of Light. The Diameter of the Image made by the Rays passing through a Convex Glass. See p. 73, 74. Also, Part 1, B. 1, P. 8. If the Theory of making Telescopes could at length be fully brought into practice, yet there would be certain bounds beyond which they could not perform: For the Air through which we look at the Stars, is in a perpetual tremor; as may be seen by the shadows of high Towers; and by the twinkling of the fixed Stars. But these Stars do not twinkle when viewed through Telescopes which have large Apertures. For the Rays of Light which pass through divers parts of the Aperture, tremble each of them apart, and by means of their various and sometimes contrary tremors, fall at one and the same time upon different points in the bottom of the Eye, and their trembling Motions are too quick and confused to be perceived severally.

And all these illuminated points, constitute one broad lucid point, and cause the star to appear broader than it is.

A Table shewing the distance of the Visible Horizon, for different heights of the Observer's Eye above the Sea, together with the true and apparent depression of the Visible Horizon. [See fig. 3, plate 1.]

height of the eye in feet.	dist. of the hor. in miles.	depress. of the horizon	Refrac- tion of the hor.	appt. dip. of the horizon.
1	1,25	1' 00"	0' 8"	0' 52"
2	1,75	1' 30"	0' 10"	1' 20"
3	2,12	1' 50"	0' 11"	1' 39"
4	2,5	2' 22"	0' 13"	2' 09"
5	2,75	2' 30"	0' 14"	2' 16"
6	3,0	2' 36"	0' 15 $\frac{1}{2}$ "	2' 20 $\frac{1}{2}$ "
7	3,25	2' 50"	0' 17"	2' 33"
8	3,5	3' 20"	0' 18"	2' 44"
9	3,7	3' 16"	0' 19"	2' 57"
10	3,85	3' 32"	0' 20"	3' 12"
12	4,25	3' 40"	0' 22"	3' 18"
14	4,7	4' 0"	0' 24"	3' 37"
16	5,0	4' 19"	0' 26"	3' 53"
18	5,25	4' 32"	0' 27 $\frac{1}{2}$ "	4' 4"
20	5,5	4' 45"	0' 28 $\frac{1}{2}$ "	4' 16"
24	6,0	5' 12"	0' 31"	4' 41"
28	6,5	5' 37"	0' 34"	5' 3"
32	7,0	5' 55"	0' 36"	5' 19"
36	7,4	6' 10"	0' 38"	5' 32"
40	7,8	6' 30"	0' 40"	5' 50"
42	8,0	6' 48"	0' 42"	6' 6"
48	8,5	7' 21"	0' 44"	6' 39"
54	9,0	7' 48"	0' 47"	7' 1"
59 $\frac{1}{2}$	9,5	8' 13"	0' 49"	7' 24"
66 $\frac{1}{2}$	10,0	8' 38"	0' 52"	7' 46"
95	12,0	10' 23"	1' 2"	9' 21"
130	14,0	12' 6"	1' 12 $\frac{1}{2}$ "	10' 54"
147	15,0	12' 58"	1' 18"	11' 40"
168	16,0	13' 50"	1' 23"	12' 27"
215	18,0	15' 31"	1' 33 $\frac{1}{2}$ "	14' 00"
266	20,0	17' 18"	1' 44"	15' 34"
336	24,0	20' 45"	2' 4 $\frac{1}{2}$ "	18' 40"
600	30,0	26' 00"	2' 36"	23' 24"
yards.	miles.	"	"	"
400	41,5	36' 45"	5' 00"	33' 05"
738	58,00	0' 50' 00"	3' 40"	45' 00"
800	60,14	52' 00"	5' 12"	46' 48"
1200	73,6	1' 03' 40"	6' 22"	56' 18"
1600	85,0	1' 13' 30"	7' 21"	1' 06' 9"
1 mile	89,24	1' 17' 10"	7' 43"	1' 9' 27"
miles				
1 $\frac{1}{4}$	99,75	1' 26' 15"	8' 37"	1' 17' 38"
1 $\frac{1}{2}$	109,3	1' 34' 30"	9' 27"	1' 25' 3"
1 $\frac{3}{4}$	118,0	1' 42' 00"	10' 12"	1' 31' 48"
3	126,1	1' 49' 00"	10' 54"	1' 38' 6"
	154,4	2' 13' 30"	13' 21"	2' 00' 9"

The $\angle$ of depression b A E, is $= \angle$ A C E, because the $\angle$ C A E is the comp. to each of them as by the fig. is evident.

Let C, represent the center of the earth, A the Summit of a place on its surface; g f a E a part of a great circle of the Earth; E A, a tangent to it drawn from the point of contact E; also the tangent line a h, and its parallel A b, may represent the true horizontal directions of the diff. Altitudes of the observer above the Horizon, or surface of the sea; in order to determine the inclination (or depression) of the visible Horizon, below the true, at diff. altitudes of the observer; we have given the semi-diameter of the Earth $= 3975$ miles, and the height of the observer's eye (by fig. 3) in the $\triangle$, A E C; Let A a, be $= 400$ yards. Then $\sqrt{AC^2 - EC^2} = AE$, the distance of the horizon from A. And since the $\angle$ E, is a right angle, and therefore $=$ the $\angle$ A + C; but the $\angle$ C $= \angle$ b A E of depression. Hence A C : C E $:: R : cs$ of the $\angle$ A C E of Depression.

Now $3975 \times 1760 = 6996000$ yds. $= C a = C E$, and A C $= 6996400$ yds.

by Trig. yds.

As $6996400 - 6,8448746$

: $6996000 - 6,8448498$

$:: R : cs \angle C - 36' 45'' - 9,9999752$

And R : $6996400 - 6,8448746$

: $S 36' 45'' - 8,0289740$

: $73088,5 - 4,8638486$

parts of
mile $=$ yds.

$\frac{1}{8}$ 220

$\frac{2}{8}$ 440

$\frac{3}{8}$ 660

$\frac{4}{8}$ 880

$\frac{5}{8}$ 1100

$\frac{6}{8}$ 1320

$\frac{7}{8}$ 1540

1 1760

yds. miles

Now $73088 = 41,5$ the dist. of the Horizon.

Ex. 2^d. To find the Hor. Dip. and dist of the Horizon, the Observer being one mile high.

1. As the Ear. rad. + 1 mile $= 3976 - 3,5994464$

: a c, the rad. in miles $= 3975 - 3,5993371$

$:: R . cs$ of the dip $- 1^\circ 17' 10'' - 9,9998907$

2. R : the Hyp. C A, } $1^\circ 17' 10'' - 8,3511194$

$:: s.$ of dip. the $\angle$ C }

: Diff. of the vis. hor. AE $- 89,24 - 1,9505658$

To find A a. As cs, of the $\angle$ of depres. : R :: C E : C A and C A $- C E = A a$.

Note, that if any number in the first column be multiplied by four, and its corresponding number in the second column by two, the products will shew the alt. of the observer, and the dist. of the vis. hor. Since the rays of the hor. are refracted (as in the fourth column) that quantity must be taken from the angle of the dip. obtained by calculation, as in the third col, to get the appt. dip. as in the fifth col,

A new Table of Refractions, adapted to the middle State of the Air.

Ap. Alt. Refrac.				Ap. Alt. Refrac.				Ap. Alt. Refrac.				Ap. Alt. Refrac.				TABLE II.			
°	'	"		°	'	"		°	'	"		°	'	"		A Table of the Minutes to be applied to the observed Altitude of the lower Limb of the Sun.			
0	0	33	0,0	6	50	7	30,2	19	30	2	39,4	62	0	0	30,4	App. Alt. of lower Edge of the Sun, the Horizontal dip being 4' Min. subf. or add. fr. or to the ap. Alt of lower Edge of the Sun obsf.			
	5	32	10,4	7	0	7	20,5	20	0	2	35,1	63			29,1				
10	31	22,2	7	10	7	11,1	20	30	2	31,0	64			27,8					
15	30	35,4	7	20	7	2,1	21	0	2	27,2	65			26,5					
20	29	49,7	7	30	6	53,4	21	30	2	23,6	66			25,3					
30	28	22,3	7	40	6	45,1	22	0	2	20,3	67			24,1					
30	28	4,8	7	50	6	37,1	23		2	13,7	68			22,9					
30	27	30,3	8	0	6	29,4	24		2	7,4	69			21,7					
40	26	59,7	8	10	6	22,0	25		2	1,6	70			20,6					
50	25	41,8	8	20	6	14,8	26		1	56,2	71			19,5					
1	0	24	28,6	8	30	6	8,0	27		1	51,2	72			18,4	from 0 to 5 Subt 21			
1	10	23	19,8	8	40	6	1,3	28		1	46,6	73			17,3			5 to 10 ditto 20	
1	20	22	15,2	8	50	5	54,8	29		1	42,4	74			16,2			10 to 16 ditto 19	
1	30	21	14,7	9	0	5	48,5	30		1	38,4	75			15,1			16 to 22 ditto 18	
1	40	20	17,9	9	10	5	42,4	31		1	34,6	76			14,0			22 to 28 ditto 17	
1	50	19	24,8	9	20	5	36,5	32		1	31,0	77			13,0			28 to 36 ditto 16	
2	0	18	35,0	9	30	5	30,9	33		1	27,6	78			12,0			36 to 44 ditto 15	
2	10	17	48,4	9	40	5	25,4	34		1	24,4	79			11,0			44 to 52 ditto 14	
2	20	17	4,5	9	50	5	20,0	35		1	21,4	80			10,0			52 to 60 ditto 13	
2	30	16	23,8	10	0	5	14,8	36		1	18,5	81			9,0				
2	40	15	45,4	10	15	5	7,3	37		1	15,7	82			8,0	fr. 1 to 1 8 ditto 12			
2	50	15	9,4	10	30	5	0,1	38		1	13,0	83			7,0			to 1 16 ditto 11	
3	0	14	35,6	10	45	4	53,2	39		1	10,4	84			6,0			to 1 26 ditto 10	
3	10	14	3,9	11	0	4	46,6	40		1	7,9	85			5,0			to 1 36 ditto 9	
3	20	13	34,1	11	15	4	40,3	41		1	5,5	86			4,0			to 1 48 ditto 8	
3	30	13	6,2	11	30	4	34,3	42		1	3,3	87			3,0			to 2 0 ditto 7	
3	40	12	39,6	11	45	4	28,6	43		1	1,1	88			2,0			to 2 13 ditto 6	
3	50	12	14,7	12	0	4	23,2	44			59,0	89			1,0			to 2 28 ditto 5	
4	0	11	51,1	12	20	4	16,1	45			57,0	90			0,0			to 2 45 ditto 4	
4	10	11	28,9	12	40	4	9,4	46			55,0							to 3 2 ditto 3	
4	20	11	7,9	13	0	4	3,0	47			53,1					to 3 20 ditto 2			
4	30	10	48,0	13	20	3	56,9	48			51,2					to 3 42 ditto 1			
4	40	10	29,2	13	40	3	51,1	49			49,4					to 4 10 — 0			
4	50	10	11,3	14	0	3	45,5	50			47,6					to 4 40 Add 1			
5	0	9	54,3	14	20	3	40,1	51			45,9					to 5 16 ditto 2			
5	10	9	38,2	14	40	3	34,9	52			44,2					to 5 56 ditto 3			
5	20	9	22,8	15	0	3	29,9	53			42,6					to 6 48 ditto 4			
5	30	9	8,0	15	30	3	23,7	54			41,1					to 8 00 ditto 5			
5	40	8	54,0	16	0	3	16,9	55			39,6					to 9 30 ditto 6			
5	50	8	40,6	16	30	3	10,5	56			38,2					to 11 40 ditto 7			
6	0	8	27,8	17	0	3	4,5	57			36,8					to 15 ditto 8			
6	10	8	14,9	17	30	2	58,9	58			35,5					to 20 ditto 9			
6	20	8	2,8	18	0	2	53,6	59			34,2					to 30 ditto 10			
6	30	7	51,1	18	30	2	48,6	60			33,0					to 50 ditto 11			
6	40	7	40,3	19	0	2	43,9	61			31,7					50 to 90 ditto 12			

TABLE II.

A Table of the Minutes to be applied to the observed Altitude of the lower Limb of the Sun.

App. Alt. of lower Edge of the Sun, the Horizontal dip being 4' Min. subf. or add. fr. or to the ap. Alt of lower Edge of the Sun obsf.

from	to	Subt	
0	5	ditto	21
5	10	ditto	20
10	16	ditto	19
16	22	ditto	18
22	28	ditto	17
28	36	ditto	16
36	44	ditto	15
44	52	ditto	14
52	60	ditto	13

fr. I	to	ditto	
1	8	ditto	12
1	16	ditto	11
1	26	ditto	10
1	36	ditto	9
1	48	ditto	8
2	0	ditto	7
2	13	ditto	6
2	28	ditto	5
2	45	ditto	4
3	2	ditto	3
3	20	ditto	2
3	42	ditto	1
4	10	—	0
4	40	Add	1
5	16	ditto	2
5	56	ditto	3
6	48	ditto	4
8	00	ditto	5
9	30	ditto	6
11	40	ditto	7
15		ditto	8
20		ditto	9
30		ditto	10
50		ditto	11
90		ditto	12

Height of Eye.	Ap. Dip of Hor.
Feet.	Min.
4	1,9
6	2,3
8	2,7
10	3,0
12	3,3
14	3,6
16	3,9
18	4,1
20	4,3
24	4,7
28	5,0
34	5,5
40	6,0

In fig. 5. Let r, r, r , be rays of light, which enter the denser part of the Atmosphere at 1, 2, 3, through which they pass to the points 5, 6, 7, where the Ray at 5 enters the glass medium, and is refracted towards the perpendicular 5 b, till it arrive at 8, where it enters the water medium, and is there refracted towards the perpendicular b e; at 9 it enters the air, and is refracted from the perpendicular 9 f, into the curve 9 i o; the other Rays $r 2, r 3$, will be bent and refracted, as appears in the figure, by principles before mentioned.

In this, the body a f g b, represents a square prism of glass, put into a vessel of water of a similar form.

The Ray, $r 3$, enters the Atmosphere perpendicularly, and therefore is not bent till it enters the glass vessel which holds the water at 7, and when it enters the water it will be bent the contrary way, and then pass in a right line to t, where it will be bent the same way as it was at 7; and if it be there refracted, so as to pass in a line perpendicular to the surface of a prism, where it entered; it will proceed in that right line through the water and the side of the glass at v, and at entering the air it will be bent towards the greatest body of the Atmosphere, into the curve v u, and the like of any other. The angle of incidence of a ray being given at its entering into any of the mediums; its inclination may be determined at any point, in its passage through the different mediums of glass and water. The sine of Incidence to that of Refraction out of air into water, being as 4 : 3, and out of air into common glass as 17 : 11, and out of air into crystal as 25 : 16, which reduced to the ratio of unity will be, the

Sine of Incidence, Sine of Refraction	
out of Air into Water, as	1 to 0,75000
out of Air into Plate Glass	1 to 0,64700
out of Air into Flint Glass	1 to 0,64516
out of Air into Rock Crystal	1 to 0,4600
out of Water into Flint Glass	1 to 0,86020

If Light pass through many Refractive Mediums, gradually denser and denser, which terminate with parallel Surfaces, the sum of all the Refractions will be equal to the single Refraction, which it would have suffered in passing immediately out of the first Medium into the last. Newton's Optics, book 2, part 3, prop. 10.

The Parallaxes of Altitude, are to each other as the Cosines of the apparent Altitudes. To find the Parallax of Alt. you must get the Horizontal Parallax at that time, and then say, as R : Hor. parx. :: c s, appt. alt. : parx. of alt. Suppose the D's Hor. Parx. 53', appt. alt. 30°,

Then Logistical log. of 53' 00" = 10,5310 Rad. added
Sub. c s, of appt. alt. 30° = 9,9375

L. L. of Parx. of alt. 45' 54" = 0,5935 by this Method the following Table was computed.

All celestial objects appear higher than they are by refraction; and lower than they are by parallax. Consequently the altitudes observed, must be lessened by the refraction of that alt. and increased by the quantity of the parallax of that altitude, as in the tables. Note. The table following with the appt. alt. against it, and under the present hor. parallax (as found in the Nautical Ephemeris) you will have the present parallax of altitude.

A Table of the Moon's Parallax of Altitudes.

Horizontal Parallax of the Moon.

D's ap alt. °	53'	54'	55'	56'	57'	58'	59'	60'	61'	dif.
1	52 59	53 59	54 59	55 59	56 59	57 59	58 59	59 59	60 59	60
2	52 57	53 57	54 57	55 57	56 57	57 57	58 57	59 57	60 57	60
3	52 55	53 55	54 55	55 55	56 55	57 55	58 55	59 55	60 55	60
4	52 52	53 52	54 51	55 51	56 51	57 51	58 51	59 51	60 51	60
5	52 48	53 47	54 47	55 47	56 47	57 47	58 47	59 46	60 46	60
6	52 43	53 42	54 42	55 41	56 41	57 41	58 41	59 40	60 40	60
7	52 36	53 36	54 35	55 35	56 34	57 34	58 34	59 33	60 33	60
8	52 29	53 28	54 27	55 27	56 26	57 26	58 25	59 25	60 24	59
9	52 21	53 20	54 19	55 19	56 18	57 17	58 17	59 16	60 15	59
10	52 12	53 11	54 10	55 09	56 08	57 07	58 06	59 05	60 04	59
11	52 02	53 00	53 59	54 58	55 57	56 56	57 55	58 54	59 53	59
12	51 51	52 49	53 47	54 46	55 45	56 43	57 42	58 41	59 39	58
13	51 39	52 37	53 35	54 34	55 32	56 31	57 29	58 27	59 26	58
14	51 25	52 23	53 21	54 20	55 18	56 16	57 14	58 12	59 10	58
15	51 12	52 09	53 07	54 05	55 03	56 01	56 59	57 57	58 54	58
16	50 57	51 54	52 52	53 50	54 47	55 45	56 42	57 40	58 38	57
17	50 41	51 39	52 36	53 33	54 30	55 28	56 25	57 22	58 20	57
18	50 24	51 21	52 18	53 15	54 12	55 09	56 06	57 03	58 00	57
19	50 07	51 04	52 00	52 57	53 53	54 50	55 47	56 44	57 40	57
20	49 48	50 45	51 41	52 37	53 33	54 30	55 26	56 23	57 19	56
21	49 29	50 25	51 21	52 17	53 13	54 09	55 05	56 01	56 57	56
22	49 09	50 05	51 00	51 56	52 51	53 47	54 42	55 38	56 33	56
23	48 47	49 42	50 37	51 33	52 29	53 24	54 19	55 14	56 09	56
24	48 25	49 20	50 14	51 09	52 04	52 59	53 54	54 49	55 43	55
25	48 02	48 56	49 50	50 44	51 39	52 34	53 28	54 23	55 17	55
26	47 38	48 32	49 26	50 19	51 11	52 07	53 01	53 55	54 49	54
27	47 13	48 07	49 00	49 54	50 47	51 41	52 34	53 27	54 21	54
28	46 47	47 40	48 33	49 26	50 19	51 12	52 05	52 58	53 51	53
29	46 21	47 14	48 06	48 58	49 51	50 44	51 36	52 28	53 21	52
30	45 54	46 46	47 38	48 30	49 22	50 14	51 06	51 57	52 49	52
31	45 26	46 17	47 08	47 59	48 51	49 42	50 34	51 25	52 17	51
32	44 57	45 47	46 38	47 29	48 20	49 11	50 02	50 53	51 44	51
33	44 27	45 17	46 07	46 57	47 48	48 38	49 28	50 18	51 09	50
34	43 57	44 46	45 36	46 25	47 15	48 05	48 54	49 44	50 34	50
35	43 25	44 14	45 03	45 52	46 41	47 30	48 19	49 08	49 58	49
36	42 52	43 41	44 30	45 18	46 07	46 55	47 44	48 33	49 21	49
37	42 19	43 07	43 55	44 43	45 31	46 19	47 07	47 55	48 43	48
38	41 46	42 32	43 20	44 07	44 55	45 42	46 29	47 16	48 04	47
39	41 11	41 58	42 44	43 31	44 17	45 04	45 51	46 37	47 24	47
40	40 36	41 22	42 08	42 54	43 40	44 26	45 12	45 58	46 44	46
41	40 00	40 45	41 30	42 16	43 01	43 46	44 31	45 16	46 02	46
42	39 23	40 08	40 52	41 37	42 21	43 06	43 51	44 35	45 20	45
43	38 46	39 29	40 13	40 57	41 41	42 25	43 09	43 53	44 37	44
44	38 08	38 51	39 34	40 17	41 00	41 43	42 26	43 10	43 53	43
45	37 29	38 11	38 53	39 36	40 18	41 00	41 43	42 25	43 08	42½

A Table of the Moon's Parallax of Altitude.

Horizontal Parallax of the Moon.

D's appt. alt.	53'		54'		55'		56'		57'		58'		59'		60'		61'		diff. 60"
0	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"
46	36	49	37	30	38	12	38	54	39	35	40	17	40	59	41	41	42	22	42
47	36	09	36	49	37	30	38	11	38	52	39	33	40	14	40	55	41	36	41
48	35	28	36	08	36	48	37	28	38	08	38	48	39	28	40	08	40	49	40
49	34	46	35	25	36	05	36	44	37	23	38	02	38	42	39	21	40	01	39
50	34	04	34	42	35	21	35	59	36	38	37	17	37	55	38	34	39	13	39
51	33	21	33	59	34	37	35	14	35	52	36	30	37	07	37	45	38	23	38
52	32	38	33	16	33	52	34	29	35	05	35	42	36	19	36	56	37	33	37
53	31	54	32	30	33	06	33	42	34	18	34	54	35	30	36	06	36	42	36
54	31	09	31	44	32	19	32	55	33	30	34	01	34	41	35	16	35	51	35
55	30	24	30	58	31	32	32	07	32	41	33	16	33	50	34	25	34	59	34
56	29	38	30	11	30	45	31	19	31	52	32	26	32	59	33	33	34	06	34
57	28	52	29	24	29	57	30	30	31	02	31	35	32	08	32	41	33	13	33
58	28	05	28	37	29	08	29	40	30	12	30	44	31	16	31	48	32	19	32
59	27	18	27	48	28	19	28	50	29	21	29	52	30	23	30	54	31	25	31
60	26	30	26	59	27	30	27	59	28	30	28	59	29	30	30	00	30	30	30
61	25	42	26	11	26	40	27	09	27	38	28	07	28	36	29	05	29	31	29
62	24	53	25	21	25	49	26	17	26	45	27	13	27	42	28	10	28	38	28
63	24	04	24	31	24	58	25	25	25	52	26	20	26	47	27	14	27	41	27
64	23	14	23	40	24	06	24	33	24	59	25	25	25	52	26	18	26	44	26
65	22	24	22	49	23	14	23	40	24	05	24	30	24	56	25	21	25	46	25
66	21	33	21	57	22	22	22	47	23	11	23	35	23	59	24	24	24	48	24
67	20	42	21	05	21	29	21	53	22	16	22	30	23	03	23	26	23	50	23
68	19	51	20	13	20	36	20	58	21	21	21	43	22	06	22	29	22	51	22
69	19	00	19	21	19	43	20	04	20	26	20	47	21	08	21	30	21	51	21
70	18	08	18	28	18	49	19	09	19	30	19	50	20	12	20	31	20	51	20
71	17	16	17	35	17	54	18	14	18	34	18	53	19	13	19	32	19	51	19
72	16	23	16	41	16	59	17	18	17	37	17	55	18	14	18	33	18	51	18
73	15	30	15	48	16	05	16	23	16	40	16	58	17	15	17	33	17	50	17
74	14	37	14	54	15	10	15	27	15	43	15	59	16	16	16	33	16	49	16
75	13	43	13	59	14	14	14	30	14	46	15	01	15	16	15	32	15	48	16
76	12	49	13	04	13	19	13	33	13	48	14	02	14	16	14	31	14	46	15
77	11	55	12	09	12	23	12	36	12	50	13	03	13	16	13	30	13	44	14
78	11	01	11	14	11	26	11	38	11	51	12	03	12	16	12	29	12	41	13
79	10	07	10	19	10	30	10	41	10	53	11	04	11	15	11	27	11	39	12
80	9	12	9	23	9	34	9	44	9	54	10	04	10	15	10	26	10	36	11
81	8	18	8	28	8	37	8	46	8	55	9	04	9	14	9	24	9	34	10
82	7	23	7	32	7	40	7	48	7	56	8	04	8	13	8	22	8	30	9
83	6	29	6	36	6	43	6	50	6	57	7	04	7	12	7	20	7	27	8
84	5	34	5	40	5	46	5	52	5	58	6	04	6	10	6	17	6	23	7
85	4	39	4	44	4	49	4	54	4	59	5	04	5	09	5	15	5	20	6
86	3	43	3	47	3	51	3	55	3	59	4	03	4	08	4	12	4	16	5
87	2	48	2	51	2	54	2	57	3	00	3	03	3	06	3	09	3	13	3
88	1	53	1	55	1	56	1	58	2	00	2	02	2	04	2	06	2	08	2
89	0	59	0	59	0	59	0	59	1	00	1	01	1	02	1	03	1	04	1
90	0	00	0	00	0	00	0	00	0	00	0	00	0	00	0	00	0	00	0

Of the Solar System.



THE parallax* of the sun deduced from the observations made the sixth of June 1761, on the day of the Transit, was $8''.565$; and on the third of June 1769, on the day of the transit it was $8''.65$, which reduced to the mean distance of the sun from the earth, gives the mean parallax of the Sun $8''.75$ or $8''.78$. The late ingenious and excellent Astronomer, Mr. James Short, deduced the Sun's parallax from a great number of calculations; the mean of 53 calculations gave $8''.61$; the mean of 63 gave $8''.63$; the mean of 21 gave $8''.56$ and $8''.57$ on the supposition that the sun's parallax was $8\frac{1}{2}''$.

And the Rev. Mr. Hornsby, Professor of Astronomy at the University of Oxford, by supposing the sun's parallax $9''$ deduced from a mean of 14 calculations $8''.69$ and $8''.65$; whose mean is $8''.67$ from the observations of the year 1761. And from the observations of 1769 (on the day of the transit) the mean result, give the parallax $8''.65$; from which this Rev. Professor, by the foregoing results, gets $8''.78$ the sun's parallax, at a mean distance from the earth; and the dimensions of the solar system.

The distances of the Planets from the Sun, as under:

The Planets	Relative Dist.	Absolute Distances	By means of an acromatic object glass micrometer 40 feet focus, which Mr. J. Short adapted to a reflecting telescope of two feet focal length, he measured the greatest and least diameters of the Sun; and found the apogeal diam. = $31' 28''$ and the perigeal diameter = $32 33$
Mercury	387,10	36,281,700	
Venus	723,33	67,795,500	
Earth	1000,00	93,726,900	
Mars	1523,69	142,818,000	
Jupiter	5200,98	487,472,000	
Saturn	9540,07	894,162,000	

We suppose the fixed Star Sirius to be }
27000 times further from us than the Sun. }

the mean of them $32 00,5$
it's half is $16 00, \frac{1}{4}$

To find the Diameter of the Sun in English Miles.

In fig. 6. Let E, represent the center of the earth; S that of the sun; and UL his diameter. Then in the right angled $\triangle ESU$, are given ES, and the angle UES, to find SU.

* The Parallax of the Sun, Moon or Star, is the greatest at the Equator, that semi-diameter being the greatest.

As R. dist. $93726900 = 7,9718643$ } And the equatoreal diameter of the
 :: s. of $\frac{1}{2}$ diam. $0^{\circ} 16' 00'', 25 = 7,6679575$ } earth being 7970 miles; as deduced from
 : $\frac{1}{2}$ the diam. $436336,5 = 5,6398218$ } the measures of a degree of the arches of
 Hence 872673 is the diam. in } meridians. Hence $7970 \mid 872673 \mid 109\frac{1}{2}$
 _____ miles } times, that the diameter of the sun is
 greater than the Earth's. But from a
 mean of a number of the measured diameters of the sun, with micrometers, there
 results for the diameter $32' 02''$, and of the planets, reduced to the mean distance
 of the earth from the sun, as are in the following table; and from which I have
 calculated their absolute diameters, circumferences, and surfaces. The mean
 angular diameter of the sun $32' 02''$ gives his diameter 109,58 times that of the
 Earth's.

On the day of the Transfit 1769, the relative distance of the sun from the
 earth was _____ } The apparent diameter of Venus
 and of Venus from the Sun $101512,6$ } was $57,8''$ measured on the face of the
 _____ } sun; but the sphere of Venus being
 of Venus from the earth $72626,3$ } so strongly illuminated, which in some
 _____ } small degree might lessen it's appa-
 rent diameter. We therefore take $58''$ for the diameter of Venus.

Whence, if $101512,6$ give $8'',6$; the relative mean dist. 100000 will give : $8'',73$;
 and if ditto give $8,65$ ditto 100000 will give $8,78$

the Mean is $8,755$;

but we will take $8\frac{1}{4}''$ for the parallax of the Sun at the mean distance from the Earth.

And it will be, as $28886,3 : 58'' :: 100000 : 16'',75388$
 and _____ : $57,8 ::$ _____ : $16,69628$

mean $16'',725$ diam. of Venus.

Log. of Sun's mean dist. $7,9718643$	Log. of $3,1415926536 = 0,4971499$
s. of $\frac{16,72}{2} = 8'',36 = 5,6070798$	Diam. $7585,3 = 3,8799728$
$\frac{1}{2}$ diam. of Venus $3792,66 = 3,5789441$	Periphery $23830 = 4,3771227$
diam. of Venus $7585,32$	Surface $180757125 = 8,2570955$

By the same method of calculation I have obtained the diameters, peripherys
 and surfaces of the other planets..

Diameters reduced to the mean dist. of the ☉ fr. the ☉		Equatoreal di- ameters in mi.	Peripherys in Miles.	Surfaces sq. miles.
Of the Sun	32' 02" —	873355,4	2743722½	2,396,241,111,110
— Earth	—	7970,0	25038½	199,556,845
— Moon	0' 04",915	2226,0	6993,2	15,566,836
— Mercury	0 7,	3148,2	9890,4	31,136,843
— Venus	0 16,7	7585,3	23830,0	180,757,125
— Mars	0 11,4	5162,5	16208,5	83,728,000
— Jupiter	3 13,7	88000,0	276460,0	24,895,186,000
— Saturn	2 51,7	78020,0	245107,0	19,123,253,000
— ♄'s Ring	6 40,6	181980,0	571707,0	104,040,000,000

Ratio of the Planets, to that of the Earth being 1.				
Diameters		Surfaces, that of the Earth's 1.		
☉	109,58	11982 times greater than the Earth's	☉	the Sun
☉	1,00	— 1	☉	the Earth
☾	0,28	— $\frac{1}{13}$ or 13 times less than the Earth's	☾	the Moon
☿	0,395	— $\frac{1}{6}$ or 6 times less than the Earth's	☿	Mercury
♀	0,952	— $\frac{1}{10}$ or $\frac{1}{10}$ less than the Earth's	♀	Venus
♂	0,648	— $\frac{1}{10}$ or $\frac{42}{100}$, not half the Earth's	♂	Mars
♃	11,04	— 125 times the Earth's Surface	♃	Jupiter
♄	9,79	— 96 times ditto	♄	Saturn
Ring of ♄	22,836	— 520 times ditto		

Remarks. Of the decrease of the Obliquity of the Ecliptic.

1. The annual precession of the Equinoxes being 50",3 as by Mr. Mayer, or 50' 18" in 60 years. The obliquity of the Ecliptic in the year 1756 was 23° 28' 16"; and in the year 1790 it will be 23° 28'. And, since the decrease of the obliquity is 1' in 130½ years, or 7' in 913 years, therefore in 7826 years the obliquity will be one degree less; and in 180000 years the obliquity will be 23° less; and therefore only 28' obliquity, or the greatest declination, that the sun will then have, according to the tables of our modern Astronomers.

2. When this happens, the days and nights will be equal all over the habitable earth, all the year round, and for many thousand years, the variation will be very little, since the decrease is so little as one degree in 7826 years. Whence in the year 181790 the obliquity will be only 28 minutes. And in the year A. C. 185443 the planes of the Equinoctial and Ecliptic will coincide, and therefore no obliquity, nor variation in the length of days.

To find the Distance of the ☉ and ♀, or ♀ and Star, at the time of an Observation, by the Ephemeris.

The calculated distances in the first column of the Ephemeris are adapted to noon, at the meridian of Greenwich, and the other columns contain the distances, at 3, 6, 9, 12, 15, 18, and 21 hours, after the preceding noon; and all observations must be reckoned in like manner, as by remark 1, p. 11.

Note 1. If the true time of observation at the Ship, reduced to the meridian of Greenwich (by remark 2, p. 11) be betwixt noon and 3pm, then take out the distances in the column under noon, against the day of the Month; and under it write the distance at 3, and take the difference of these distances, and then say, As 3 hours or 180 minutes, is to that difference, so is the minutes of time of the observation, after the time of the first distance, to the proportional part of increase or decrease of distance; which must be added to the distance at the former time, when the distance is increasing; but subtracted when the distance is decreasing, and you will have the distance at the time of observation by the Ephemeris.

Note 2. You are always to take out from the Ephemeris one distance at the nearest time preceding that of the reduced time of observation; [See remark, p. 22] and the next distance after it, and then proceed as above directed, see p. 17.

Note 3. Having obtained the diff. between the reduced dist. and that by the Eph. then say, as the hourly incr. or decr. of dist. obtained from the Eph. is to 15° or 900' of Long. so is the difference between the reduced dist. and that by the Eph. to the degrees or minutes of Long. resulting. See p. 17; and 22.

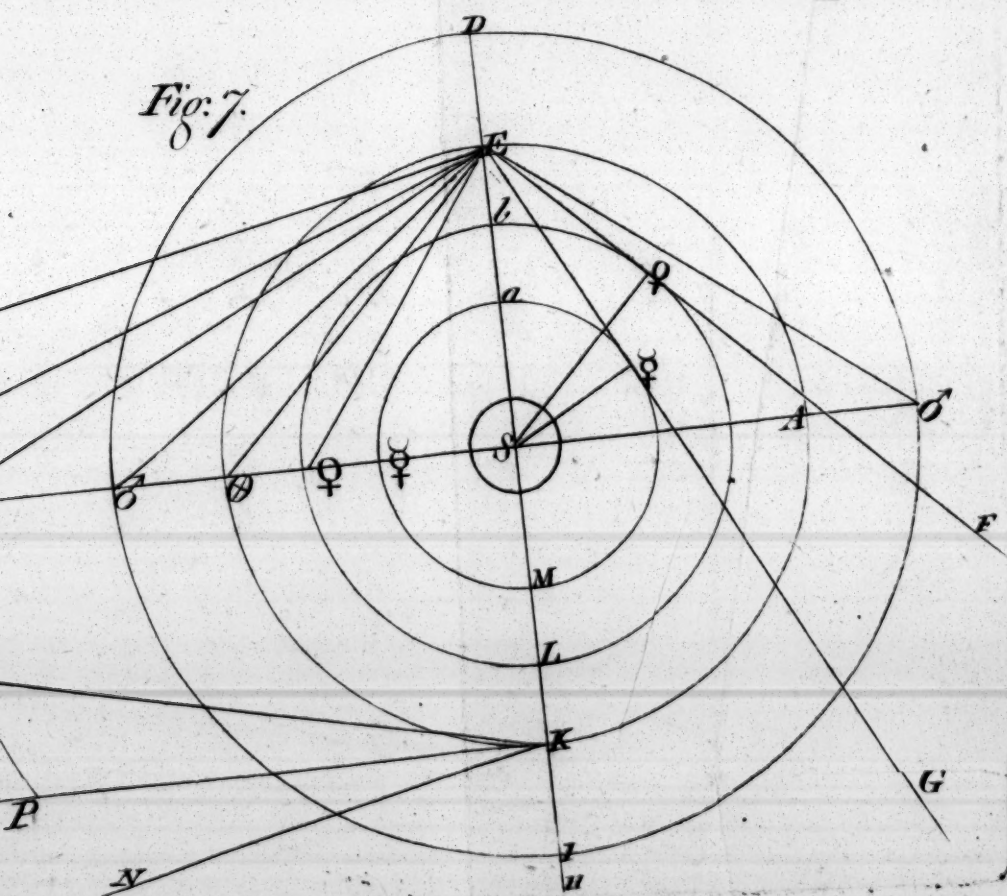
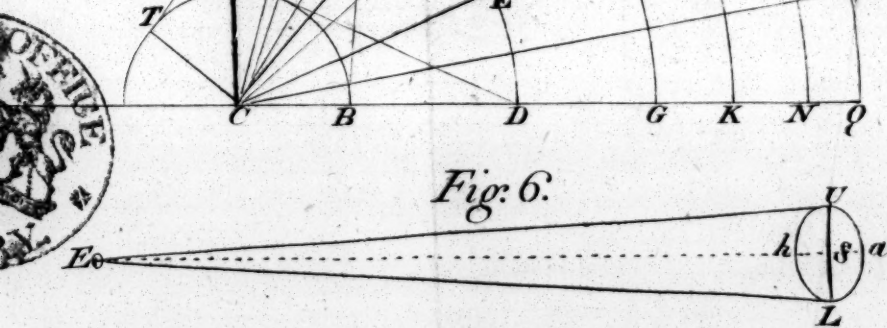
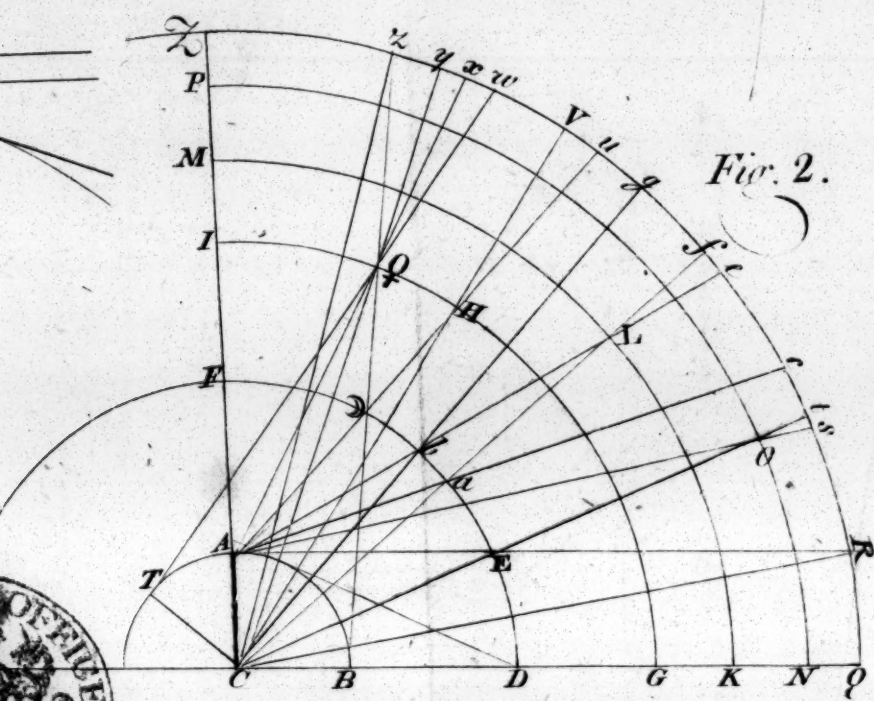
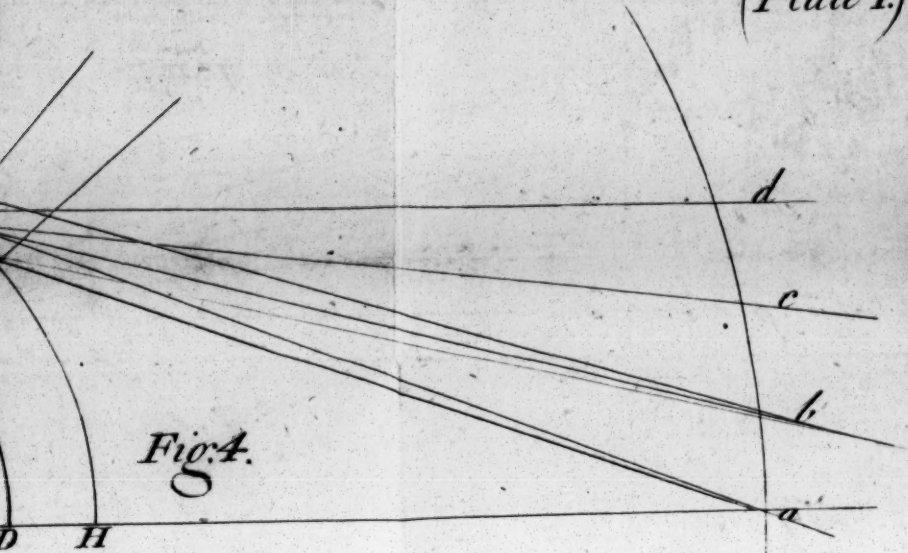
The C O N T E N T S.

Page

- 1 **O**F the Sextant, and the method to set the object and index Glasses perp. to the
- 2 Plane of the Instrument, and parallel to each other
- 3 Of the Arch and Nonius, and how to be reckoned
- 4 The method of reckoning any arch and it's Nonius
- 5 To adjust the Sextant, and how to observe the Alt. of ☉, ♀ or stars
- 6 The manner of observing distances of the ☉ and ♀, and ♀ and stars
- 8 A table to convert time into degrees and minutes, and the contrary
- 9 Of the Method of determining the Longitude at Sea
- 10 The Method of obtaining the time of an observation; and of computing the Altitude of the Sun, Moon and Star
- 11 A Table of the ri. ascen. and declin. of Stars; whose computed distances are in the Eph. and to find the angle of time, &c. to p. 14.
- 14 Three general Rules for finding the true dist. from the apparent distance observed. Having found the difference of Azimuth, by Rule 1, correct the Zenith distances. Thus, to the apparent Z. D. of the Sun, add the ref. as by tab. p. 27, and the sum will be the Sun's true Z. Distance.
From the ♀'s apparent Z. D. take the difference between the Parallax of Moon's Alt. and the Refraction of that Alt. the diff. will be the true (Z. D.) Zenith Distance of the Moon; then work by Rule 2 and 3, and note the Remarks.
- 15, 16, and 17, Contains two Observations, computed, and the Long. determined.
- 18 A second Method, by two Canons. 19 Dunthorne's and Lyon's Methods
- 20 A fifth Method. 21, 22, A Table to find the Longitude by the difference between the observed Distance and that by the Ephemeris.
- 23, 24, and 25, Of Refraction. 26 A Table. 27 A Table of Refraction, and a Table of the Minutes to be added or deducted from observed Altitudes to get the true Altitudes.
- 28 Of the Parallax of the Moon, Planets, &c.
- 29, 30 A Table of the Moon's Parallax of Altitude.
Of the Solar System,



(Plate 1.)



PATENT OFFICE LIBRARY



